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ROYAL BOTANIC GARDENS, SYDNEY
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CUNNINGHAMIA

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Ecological contributions from the National Herbarium of New South Wales

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EDITED BY J. M. POWELL

FOREWORD

Since 1969 the National Herbarium of New South Wales has been involved in mapping and describing the vegetation of New South Wales as part of its ecological programme. It has also carried out more localized vegetation surveys and detailed studies of particular plant communities for use in environmental enquiries, impact studies and conservation-value assessments. The results of these and future studies will be published in *Cunninghamia*.

Both the number and the cost of scientific journals have increased rapidly in recent years and the decision to start yet another may be questioned. There is a real need in Australia, however, to provide avenues for the publication of vegetation maps and their accompanying memoirs, and of baseline ecological data (including community descriptions and floristic lists) of value for land use and environmental impact studies. Because of the particular field of responsibility of the National Herbarium of New South Wales, papers dealing with New South Wales, or with comparative data from New South Wales and neighbouring States will be given preference over those dealing exclusively with other Australian States, or other countries; the latter will be considered on the basis of their relevance to New South Wales.

The first issue of *Cunninghamia* includes research papers and articles covering several aspects of ecology in New South Wales. Professor Noel Beadle, a pioneer in vegetation mapping of the State, kindly accepted our invitation to write an introductory article and has provided us with an interesting and lively account of an early trip through western New South Wales. The other papers indicate something of the range of investigations and data which *Cunninghamia* will report. In addition, some issues will comprise exclusively descriptive memoirs accompanying vegetation maps of substantial parts of New South Wales.

The journal is named in honour of Allan Cunningham (1791–1839), Colonial Botanist and Superintendent of the Sydney Botanic Garden from March to December 1837. As Botanical Collector for the Royal Gardens at Kew, he accompanied Lieutenant John Oxley and Captain Phillip King on their early expeditions (1817–1822) and later himself explored northern parts of New South Wales and the Darling Downs of Queensland (1823–29). He collected widely in New South Wales and many other parts of Australia; his observations on topography, geology, soils, drainage patterns and other environmental factors, and comments on plant distribution patterns are amongst the earliest ecological information available in the country.

L. A. S. Johnson,
Director.

J. M. Powell,
Editor.

Cunninghamia 1 (1): 1–6 (1981)

FORTY YEARS AGO

N. C. W. Beadle*

Nineteen thirty nine was a good year in Western New South Wales (though not an exceptionally wet one) and a wealth of herbaceous growth had transformed the arid zone into a fairyland of colour. Reports reached Sydney that many species which had not been seen for a couple of decades were in flower and that some new species might possibly be found.

Some enterprising member or members of the Linnean Society of New South Wales suggested that parties of botanists should visit the area to make collections. Two groups of people were selected, one consisting of four ladies who were to travel by car to Broken Hill, thence to proceed south to Wentworth and home by a southern highway. The other group, all male, was to proceed by car to Broken Hill and then travel northward to Tibooburra and the Queensland border, returning home by a northern route.

I was lucky enough to be included in this male party led by Mr W. A. W. de Beuzeville of the Forestry Commission, who drove us without mishap along the prescribed route. The others were Dr P. Brough, Senior Lecturer in Botany at the University of Sydney, and Trevor Langford-Smith (now Professor of Geography at the University of Sydney, then a post-graduate student in the Department of Geography) (Figure 1). For me, the trip was an historic one since, soon after our return to Sydney, the newly established Soil Conservation Service of New South Wales advertised for a botanist to work on a vegetation and erosion survey of the far west of the State. Having collected plants in this area I felt that I would have some qualification for such a job, though I was soon to realize that I was really poorly equipped. Indeed, in those days no ecology at all was included in the botany course and my knowledge of the grasses consisted of a superficial look at the awn of *Stipa* and the spikelet of a *Bromus*. However, the trip of 1939 provided me with a lot of new knowledge, including illustrations of vegetation patterns in relation to soil and climate, community structure, floristic composition, succession, the idea of transects and the impact of man and his domestic stock on the stability of the natural vegetative cover.

At this point the problems associated with vegetation survey work in 1939 and 1979 may be compared. Two major strides have been made in this forty-year period. Firstly, modern students are provided with a different kind of training which equips them better for field and conservation studies, broadly classed under 'ecology'. Secondly, field workers have available aerial surveys which are invaluable for mapping. Smaller advantages of today include a better network of roads and better road surfaces, refrigeration, lighter camping gear, plastic bags and bottles, motels and caravans. But some of these have disadvantages for the modern ecologist, especially the high-speed roads which enable us to travel at such a rate that the driver, at least, and possibly the passengers, see nothing but bitumen, sometimes viewing the vegetation through the side windows as long rectangles of green.

The first part of our trip was 'modern' in so far as we sped westward to reach the plains, stopping only for essentials until we had left Dubbo. Thereafter, the mid-western eucalypts (chiefly Bimble Box—*E. populnea*) were accompanied by such tall shrubs or small trees as Myall (*Acacia pendula*, on more clayey soils), Wilga (*Geijera parviflora*), Warrior Bush (*Apophyllum anomalum*), Belah (*Casuarina cristata*), Yarran (*Acacia homalophylla*) and Wild Orange (*Capparis

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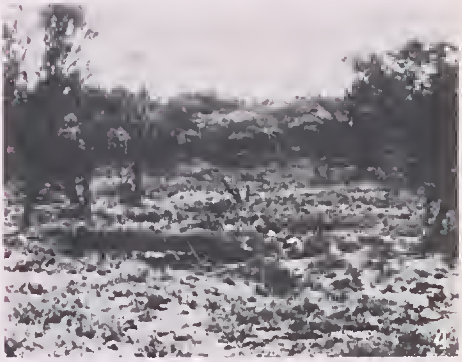
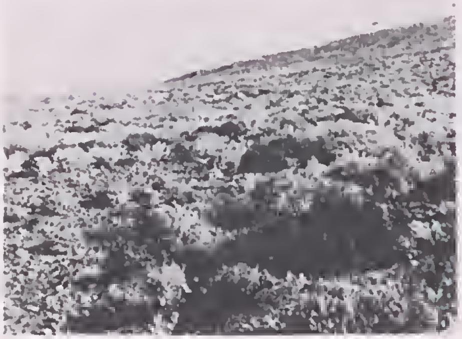




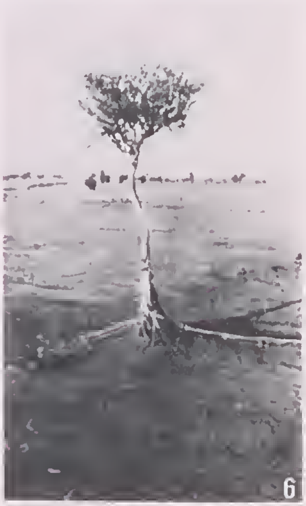


Figure 1. The members of the 1939 collecting trip (left to right: N. C. W. Beadle, W. A. W. de Beuzeville, P. Brough, T. Langford-Smith).

Figure 2. The highway, 50 miles [80 km] West of Cobar. Mulga scrub with *Heterodendrum oleifolium* and occasional trees of *Flindersia maculosa*.

Figure 3. The Darling River at Wilcannia.

Figure 4. Belah, with Mulga scrub behind. Dolo Hills area.

Figure 5. Tillite hill. *Atriplex vesicaria* and *Sclerolaena longicuspis*. Near Yanco Glen. Note Mulga on hills.

Figure 6. Soil erosion by wind; a lonely Mulga. Between Cobham Lake and Milparinka.

mitchellii). Shortly before we reached Cobar we saw our first Mulga (*Acacia aneura*) and we saw, as well, around the town of Cobar, the devastation of the Mulga country through the activities of mining companies. Fortunately, these devastated stretches of red-brown soil (some of it shiny and impervious to water as a result of the removal by erosion of the A horizon) have been revegetated over the years, partly through better mine-management and partly by the exclusion or control of stock from the degenerate scrubs which formerly covered the town common.

We left Cobar on a dirt highway (Figure 2), aiming to reach Wilcannia by nightfall. The distance to be travelled was 178 miles [285 km] and the road was uniformly bad all the way, rough and dusty, but now replaced by a magnificent 2–4-lane speedway. We travelled through scrubs of Mulga and Belah with occasional patches of Leopard Tree (*Flindersia maculosa*), except for the treeless expanses towards the west where the countryside was carpeted by everlasting daisies (*Helipterum polygalifolium* and *H. floribundum*).

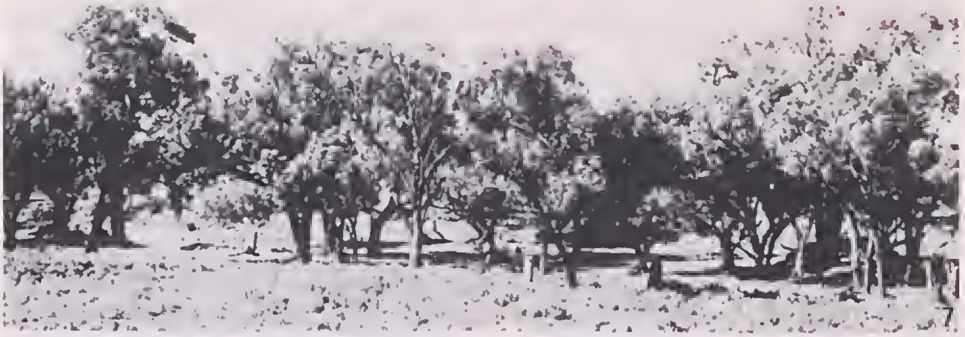
We crossed the Darling at dusk (Figure 3) and spent an uncomfortable night at the hotel in Wilcannia.

The road to Broken Hill was gravel and very dusty, carrying more traffic than the highway between Cobar and Wilcannia. We passed through many miles of Mulga scrub on gently undulating sandy country. The Dolo Hills (Figure 4) broke the monotony of the almost level terrain, but we soon plunged back into the Mulga where emus and kangaroos provided welcome diversions. A treeless tract of Perennial Saltbush (*Atriplex vesicaria*) on flat clayey country presented another change in scenery and flora, as did also the woodland of River Red Gum (*Eucalyptus camaldulensis*) edging Yancowinna Creek.

We viewed more hills as we approached Broken Hill, located on the Barrier Range which was once "covered with dense low woodlands of Mulga" (so we were told by an old lady who had lived in the area since the ore was discovered last century). The range is a refuge for many rare plant species, as are most ranges of the inland. It was difficult to understand how such bareness could be caused by the continual removal of trees by the axe, the timber being in demand for the lead-zinc ore mines and as fuel for the inhabitants of the Silver City, with a population of c. 30,000 in 1939.

This devastation of trees led to an erosion problem. The unstable red-brown sandy soil, being unprotected, was blown into the city to the irritation of the inhabitants. However, at the instigation of a professional metallurgist, the late Albert Morris, who was also an amateur botanist, fences were erected in 1937 on the western side of the city to exclude stock and to promote regeneration (see Morris, 1939). Another illustrious name associated with the Mulga is that of Miss Marjorie Collins (later Mrs Shiels) who ventured to the far west in the early twenties and, with headquarters at Corona Station, which lies northwest of Broken Hill, surveyed botanically part of the Barrier Range (Collins, 1923). Later she did a similar survey of the Grey Range (Collins, 1924) which lies further north and which we were to visit during the following week.

We left Broken Hill at noon for our adventure north. The bare hills of the Barrier Range lay to the west and the few Mulga trees on the ridges were the last remnants of the scrub. A camel team which had dragged a load of firewood some 50 miles into the city provided evidence of the fuel shortage. We had planned to reach the Fowlers Gap hotel that night, a journey of about 70 miles [112 km] north of Broken Hill. The range with its scattered Mulga lay to our left, the gibber plains with saltbush to the east (Figure 5) and we collected plants copiously from the two communities. Drying the specimens became a major problem. All the plants were literally full of water and many had succulent leaves. We had not counted on this and had not taken enough drying paper with us. Being the junior botanist, it fell to my lot to dry the specimens and most of my time of an evening was spent desiccating newspaper in front of the fire in the hotels.



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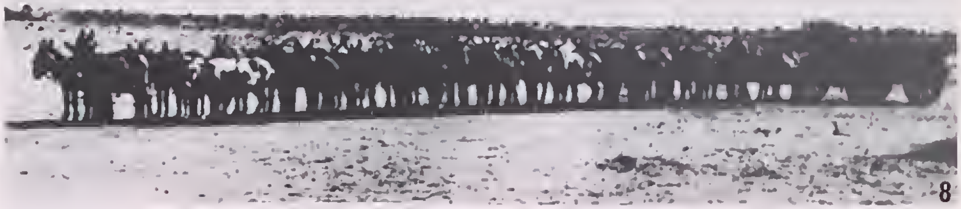

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Figure 7. Gidgee (*Acacia cambagei*) near Milparinka.
Figure 8. The tanksinker and his donkey team in degenerate Mulga country near Tibooburra.

We crossed several dry creeks edged with River Red Gum and finally reached Fowlers Gap Creek with its woodland of trees and a stone house on its northern bank. The house, a 2-roomed structure with a waterproof iron roof, was then an outstation of Corona and was occupied by a boundary rider. Later, the block of land was taken over by the Department of Conservation as a research station (see Mabbutt, 1973) when it was occupied periodically by groups of students from the University of New England. Some 15 years ago a wall of water which overtopped the eucalypts edging the creek destroyed the house, fortunately unoccupied at the time. This creek flows into Lake Bancannia, which we were to see the following day.

It was dark when we reached the Fowlers Gap hotel, but we could see that its days were numbered. Hotels along this road were located about every 20 miles [32 km] to provide for people travelling by horse-drawn vehicles. The one at Euriowie, once a tin-mining town, located some 40 miles [64 km] north of Broken Hill, had been abandoned several years before. The hotel at the Gap provided us with good meals and satisfactory accommodation. Apart from a lamp for the lounge and one candle for each room, we had no lights and the specimens had to sweat in the wet papers till lunch time the following day.

The most memorable view on the journey northward to Milparinka was the vast area of purple pea (*Swainsona swainsonioides*), which dominated the plain north of the hotel. We calculated a sheet of purple of 18 square miles [c. 50 sq. km]. The plants were copiously nodulated with rhizobial nodules.

The road led us past Lake Bancannia, with a fine supply of water complete with sea gulls on a "holiday" from the coast. The mud supported a community of the rare Australian liquorice (*Glycyrrhiza acanthocarpa*). Then more Mulga scrub (much with bad erosion, Figure 6), and saltbush downs until we reached the one-time mining town of Milparinka, which once had a population of c. 3,000 people.

The hotel, which provided travellers with meals at 2/6 each and a bed for 2/6 (i.e. 10/- or $1 per day), was owned by Mrs Bonnet, a delightful old lady with long experience in the west and a love for people in general and for her country. In spite of isolation and duststorms, the hotel was meticulously kept and the meals were beautifully cooked and served in a dining room with linoleum-covered walls. Mrs Bonnet told us much about the country, emphazising its one-time splendour and its destruction by over-grazing, mainly by sheep and later by rabbits, towards the end of last century. I remember in particular her description of the waters of Evelyn Creek, on which Milparinka stands, and of the fish that one could catch there. The creek is now full of sand. In 1939, Milparinka had a population of five people, which dropped to four when the old lady died. However, her son restored the number to five when he married. The town, built largely of stone, is now in ruins.

We were directed to Preservation Creek, where Sturt's party was stranded for 6 months and James Poole died of scurvy and was buried below a Beefwood Tree (*Grevillea striata*). There is an outlier of Gidgee (*Acacia cambagei*) on the creek, the species occurring in this area near its southern and western limit (Figure 7).

Tibooburra lies only 20 miles [32 km] north of Milparinka, and we arrived at this outpost before nightfall. The town had a main street and a few other buildings. It seemed a long way from the rest of the New South Wales towns, but was (and still is) a home for a couple of hundred people and a civic centre for many more, including Queenslanders. Many were living in isolation in the district, using old-fashioned techniques to sustain life, such as donkeys as draught animals (Figure 8). The town is located within a granite outcrop, the granite being gold-bearing. The gold is no longer abundant enough to cause a gold-rush, but from time to time small nuggets may be found after rain has fallen. Lack of water in the area precludes panning.

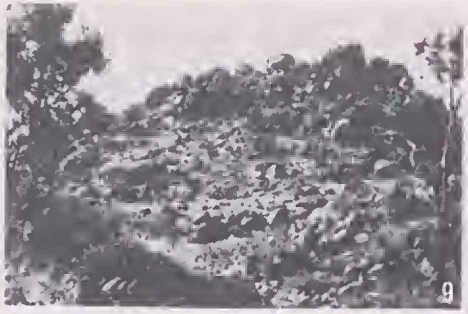
The granite outcrops support outliers of the tropical and subtropical *Eucalyptus terminalis* (Desert Bloodwood), which occurs in open woodlands or scattered clumps or as individual trees in the rugged terrain (Figure 9). A small gully, named at that time "Dead Horse Gully", was a refuge for rare species and at the same time a riot of colour produced by the yellow-flowered *Sida virgata* and the scarlet *Clianthus formosus*. Other unusual or rare species in full flower were *Prostanthera striatiflora*, *Podocoma cuneifolia* among the rocks, and *Gnephosis eriocarpa* forming mats on the sand of the valley floor.

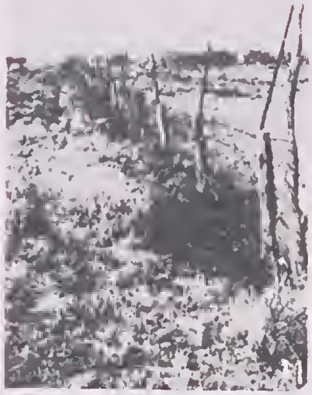
A trip to the Grey Range, another isolated refugium, and to the border fence completed our stay in the area. An aboriginal water hole (Figure 10) on the range attracted more attention than the vegetation, with which we were now becoming familiar. The border fence (Figure 11) has been erected along the state border to restrict the migration of noxious animals, rabbits moving northward and dingoes southwards. The fence is over 2 m high, the lower part being small mesh wire-netting, the upper part of larger mesh.

Our route back to Sydney took us firstly along the border fence across the Bulloo Overflow, a number of large claypans that fill with water when the Bulloo River spills out into New South Wales. There was little water to be seen and the road was easily negotiated—indeed even a speedway across the clay flats.

The plant communities were similar to those we had seen to the south on our forward journey. Mulga dominated much of the area and *Eucalyptus populnea* began to re-appear in depressions. One major difference, as we approached Wanaaring, was the occurrence in this predominantly summer-rainfall zone of *Acacia cambagei* (Gidgee), forming woodlands some 10 m tall. As is usual under humid or moist conditions, the phyllodes were emitting their offensive odour.

We stayed the night at a comfortable hotel at Wanaaring, and the following morning we lingered to examine the Paroo River. The road to Bourke led us through stands of Mulga, Gidgee and Belah, and we crossed the Darling River at Bourke into what one may call "closely settled" country.





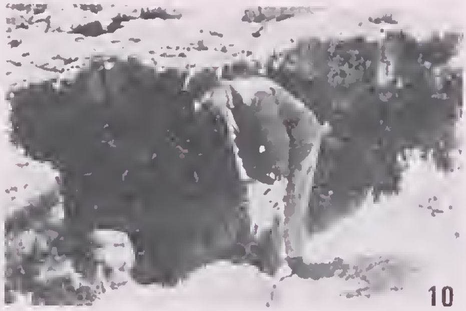


Figure 9. Granite boulders at Tibooburra. *Eucalyptus terminalis* on left.
Figure 10. Aboriginal rock waterhole.
Figure 11. Border fence near Fort Grey Gate.

Our collection consisted of almost 300 species and the trip had provided us with two transects across New South Wales and a wealth of experience which laid the foundation of my Vegetation of Western New South Wales, published in 1948.

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VEGETATION OF UPPER MANGROVE CREEK, WYONG, NEW SOUTH WALES

D. H. Benson

(Accepted for publication 20.12.1979)

ABSTRACT

Benson, D. H. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia 2000) 1981. *Vegetation of Upper Mangrove Creek, Wyong, New South Wales. Cunninghamia* 1 (1): 7–22. In a survey of 9 000 ha of the upper catchment of Mangrove Creek, Wyong, New South Wales, four types of vegetation, distinguished structurally and floristically, are described and related to physiographic and geological variation. On Hawkesbury Sandstone, *Eucalyptus eximia-E. gummifera-E. punctata* woodland occurs on ridgetops and N to W facing slopes, while *Angophora costata-Eucalyptus piperita* open-forest occurs on S to E facing slopes and in sheltered gullies. In valleys cut into Narrabeen Group shales and sandstones, *Eucalyptus tereticornis-E. eugenioides* open-forest occurs on dry aspects of the lower slopes while *Eucalyptus deanei-Angophora floribunda* tall open-forest occupies the lower slopes on sheltered S facing slopes and on Recent alluvium. The value of "forest types" for the description and mapping of vegetation is discussed.

INTRODUCTION

The vegetation of the catchment of the planned Mangrove Creek Dam is described here. The catchment covers approximately 9 000 ha of the headwaters of Mangrove Creek (lat 33° 10′ S, long 151° 10′ E) which rises approximately 30 km north-west of Wyong, and flows south to join the Hawkesbury River at Spencer. This area was included in Pidgeon's (1941) general survey of the vegetation of the Central Coast of New South Wales and the vegetation assigned to two broad plant Associations, the Mixed *Eucalyptus* Forest Association and the *Eucalyptus saligna-E. pilularis* Association. She recognized that there was considerable variation within these Associations and suggested that within them a number of "forest types" could, with further work, be recognized. The opportunity arose to see whether the vegetation could be satisfactorily described and mapped in terms of "forest types" in a catchment where much of the vegetation was, at the time, relatively little altered from its natural state.

The catchment area is on part of the Triassic Hawkesbury Sandstone plateau which covers much of the Sydney region (N.S.W. Department of Mines, 1966). Here the plateau has been dissected by Mangrove Creek and its tributaries, which have cut deep valleys through the sandstone to expose the softer shales and sandstones of the underlying Narrabeen Group, also of Triassic age. On the floors of the valleys are alluvial flats. Included in the catchment area is a small outcrop of Tertiary basalt, which has been cleared of its original native vegetation.

Climatic data for Cessnock, a similar distance from the coast as the catchment area and approximately 45 km north, are given in Figure 1.

SURVEY METHOD

Colour aerial photography (approximate scale 1:16 300) was used to map recognizable units or "phototypes". Vehicular and foot traverses were made in April and August 1976 to field-check mapped boundaries and to record detailed data from ten sites. These sites were chosen from the aerial photography to sample the different phototypes recognized and the range of variation within each phototype. Detailed recording sites were 20 x 20 m square quadrats in which all vascular plant species present were recorded. All stems with a diameter (d.b.h.) greater than 5 cm were measured, and the density and basal area for each site determined. Projected canopy foliage cover was measured at 50 points within the site, using a vertical sighting tube with cross-wires. Aspect and slope were recorded and an estimate of general canopy height was made.

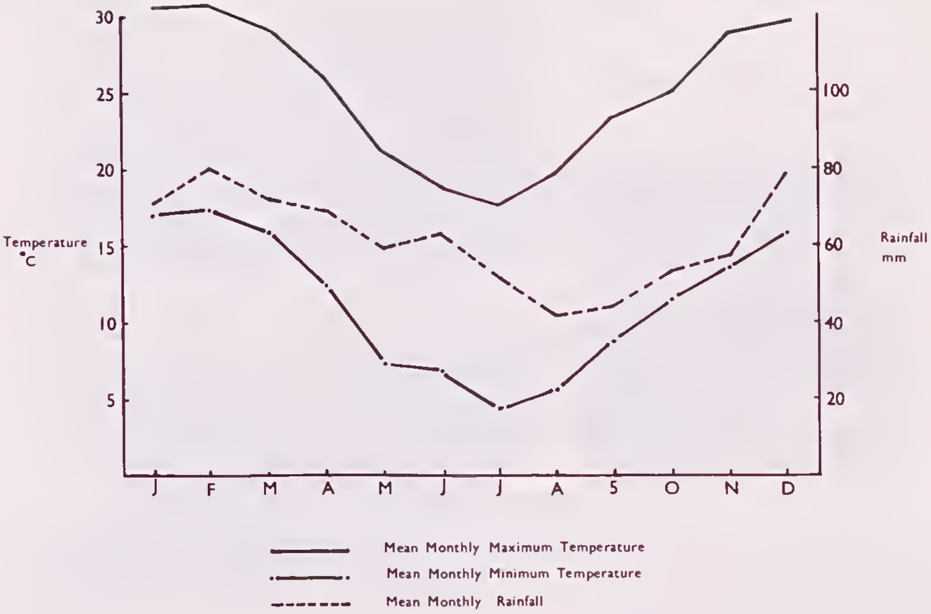


Figure 1. Climatic data for Cessnock, New South Wales, approximately 45 km north of Mangrove Creek. Data for period 1903–1964 (Hall, 1972).

THE VEGETATION

The alluvial flats were cleared in the early days of settlement, but the rest of the catchment area still retains much of the original native vegetation, though this has been regularly grazed, logged and burnt, particularly on the lower hillsides.

Only three phototypes could be distinguished: (i) tall open-forest/open-forest, (ii) woodland and (iii) cleared agricultural land. The structural formations of Specht (1970) are used. Field work enabled the tall open-forest/open-forest type to be subdivided into three floristic units, each occupying a distinctive physiographic position along a gradient from ridgetop to gully but which, because of the amount of intergradation between them, could not be mapped separately at the scale presented here (Figure 2). The relationships between the structural units mapped, the vegetation communities described, and the geology and physiography are summarized in Table 1. Descriptions of the communities are given below. Site data are given in Table 2 and Appendices 1 and 2.

Eucalyptus deanei-Angophora floribunda TALL OPEN-FOREST

This community is found in sheltered conditions with relatively fertile soil and is restricted to sheltered alluvial valleys or lower hill slopes on exposures of the Narrabeen Group, usually on southerly to south westerly aspects. It originally occupied most of the alluvial flats of Mangrove Creek down to its junction with the Hawkesbury River (Benson, 1974) but has been extensively cleared for agriculture and grazing. The original structure of the community was probably tall open-forest with very tall straight trees commonly exceeding 30 m in height. Remaining stands are now generally less than 25 m high, often composed of a large number of even-aged trees which have regenerated following clearing or extensive logging.

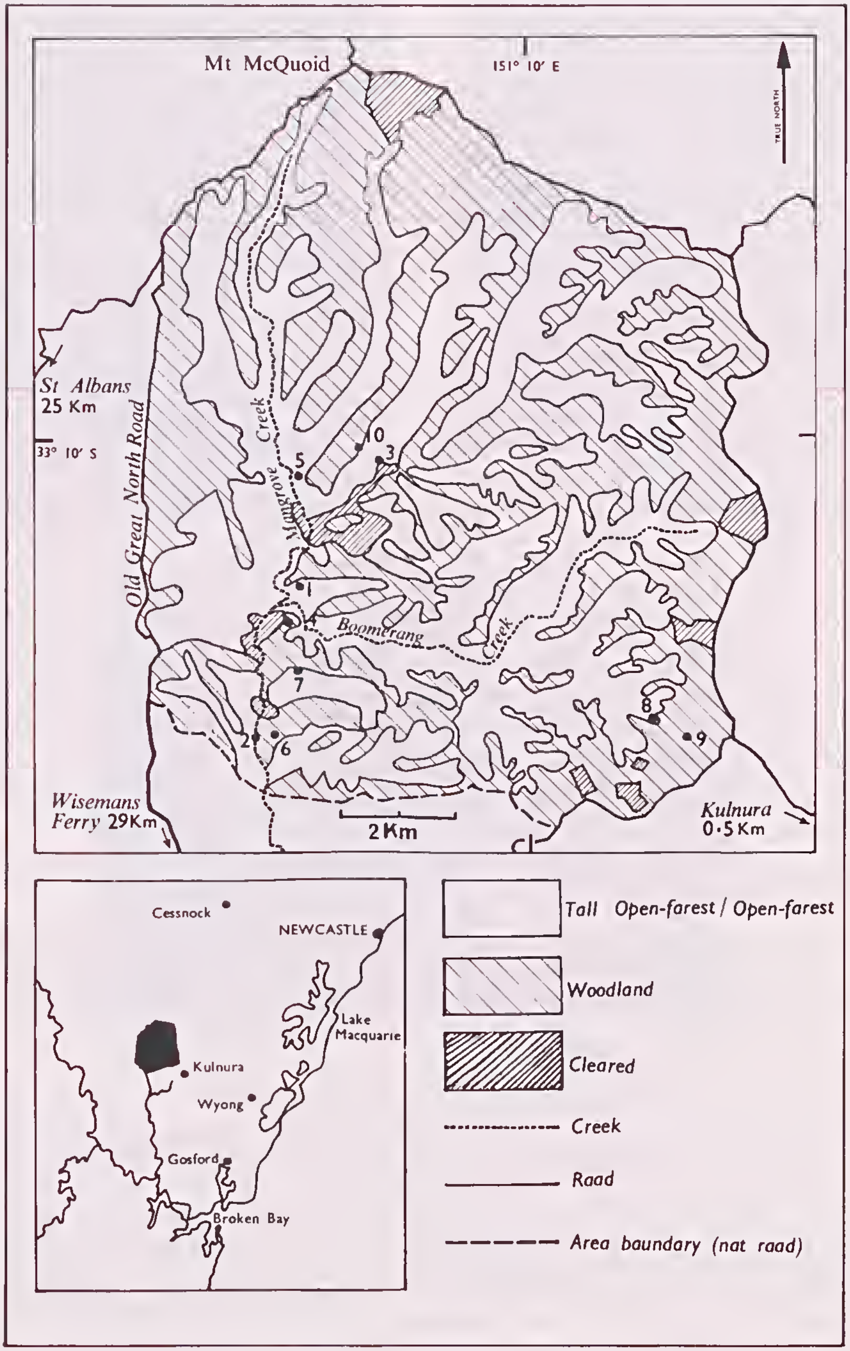


Figure 2. Vegetation of Upper Mangrove Creek catchment area. Numbers refer to sites in which structural and floristic data were recorded.

TABLE 1

Relationship between mapped units, plant communities, geology and physiography.

Mapped unit	Plant community	Geology	Physiography
Tall open-forest/open-forest	*Eucalyptus deanei-Angophora floribunda* Tall open-forest	Recent alluvium, Narrabeen Group	Sheltered valleys, S to SW facing slopes.
	Eucalyptus tereticornis-E. eugenioides Open-forest	Narrabeen Group	Lower slopes of hills, drier aspects.
	Angophora costata-Eucalyptus piperita Open-forest	Hawkesbury Sandstone	Sheltered gullies, S to E facing slopes.
Woodland	*Eucalyptus eximia-E. gummifera-E. punctata* Woodland	Hawkesbury Sandstone	Ridgetops and exposed slopes, N to W facing slopes.

The main tree species are *Eucalyptus deanei* (Deane's Gum) a tall straight smooth-barked tree, abundant in sheltered gullies, and *Angophora floribunda* (Rough-barked Apple), a rough-barked tree with twisted branches, generally shorter than *E. deanei* and more common on alluvial flats. Other canopy trees found are *Eucalyptus tereticornis* (Forest Red Gum) and *E. acmenoides* (White Mahogany). Below the main canopy may be a small-tree stratum about 8 m high of *Casuarina torulosa* (Forest Oak) and *Acacia filicifolia* (Fern-leaf Wattle). *Acacia filicifolia* is particularly abundant where the tree canopy has been opened and forms dense thickets in and around clearings. Ground cover is a dense layer of ferns and grasses, and appears to have been grazed and regularly burnt for many years. Common ground species are *Adiantum aethiopicum*, *Pteridium esculentum*, *Doodia aspera*, *Culcita dubia*, *Imperata cylindrica* and *Dichondra repens*. *Hibbertia scandens*, a small trailing shrub, is often abundant.

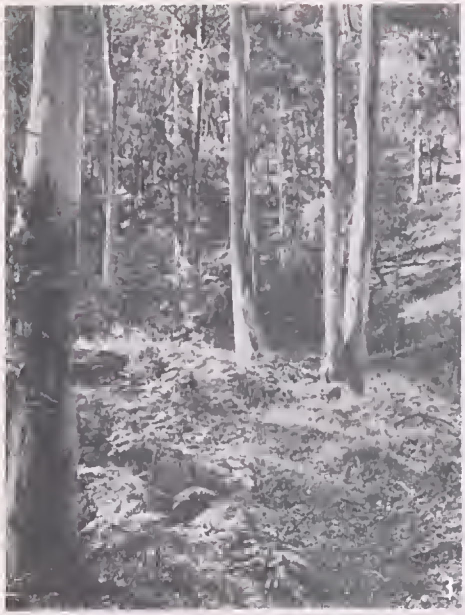
Boundaries with the drier *Eucalyptus tereticornis-E. eugenioides* open-forest are transitional.

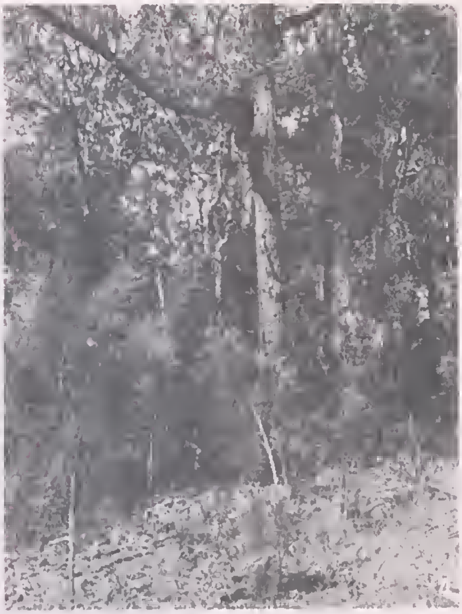
Remnants of the *Eucalyptus deanei-Angophora floribunda* tall open-forest are found also along Mogo and Wyong Creeks. This vegetation type was probably originally widespread along most creeks in the area. Samples have been preserved in Dharug National Park (Matthew, 1973) and along Mooney Mooney Creek in Brisbane Water National Park.

Eucalyptus tereticornis-Eucalyptus eugenioides OPEN-FOREST

On the drier northerly and westerly aspects on exposures of the Narrabeen Group, the *Eucalyptus deanei-Angophora floribunda* tall open-forest is replaced by an open-forest of *Eucalyptus tereticornis* (Forest Red Gum) and *E. eugenioides* (Thin-leaved Stringybark). This community ranges in height from 12 to 20 m and includes a number of other tree species such as *E. acmenoides* (White Mahogany), *E. punctata* (Grey Gum) and *E. crebra* (Narrow-leaved Ironbark). *E. deanei* and *A. floribunda* may be present on moister sites. Smaller trees of *Casuarina torulosa* and sapling eucalypts to 8 m with a discontinuous shrub layer of *Persoonia linearis* and *Jacksonia scoparia* form the understorey. Ground cover is open with grasses and small shrubs up to 0.5 m. Common species are *Pteridium esculentum*, *Imperata cylindrica* and *Hibbertia scandens*.

Boundaries with *E. deanei-A. floribunda* tall open-forest on alluvial flats are transitional, but are abrupt with the communities found on Hawkesbury Sandstone.





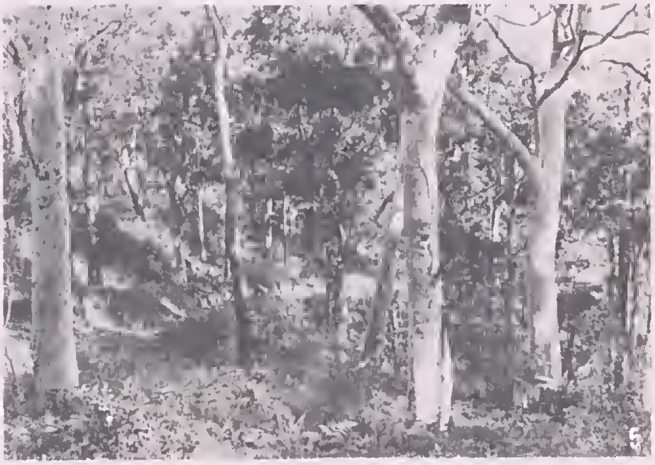


Figure 3. *Eucalyptus deanei-Angophora floribunda* tall open-forest showing *E. deanei* with *Culcita dubia* understorey and scattered shrubs of *Acacia filicifolia.*

Figure 4. *Eucalyptus tereticornis-E. eugenioides* open-forest showing *E. eugenioides* with understorey of *Jacksonia scoparia.*

Figure 5. *Angophora costata-Eucalyptus piperita* open-forest showing *Angophora costata* with *Pteridium esculentum* understorey.

Remnants of the *E. tereticornis-E. eugenioides* open-forest occur in the upper MacDonald River and Mogo Creek, though most have been cleared or partially cleared and are regularly grazed and burnt. Small examples have possibly been included in Dharug National Park.

Angophora costata-Eucalyptus piperita OPEN-FOREST

This community is confined to the Hawkesbury Sandstone and is found in moist gullies and on the sheltered sides of ridges, mainly those with easterly and southerly aspects. Tree height depends on the degree of shelter, and ranges from 26 m in sheltered gullies to less than 12 m near ridge crests.

TABLE 2

Structural and species richness data recorded from 20 x 20 m sites

Community	Number of sites	Estimated canopy height (m)	Projected foliage cover (%)	Basal area (m^2/ha)	Stem density (stems/ha)	Number of species	Total exotic species
Tall open-forest *E. deanei-A. floribunda*	3	20,20,25	44,56,60	31,37,38	250,475,850	46,57,59	4
Open-forest *E. tereticornis-E. eugenioides*	3	14,20,20	38,40,54	20,27,30	475,750,1625	43,52,57	3
Open-forest *A. costata-E. piperita*	2	12,20	54,64	25,50	225,250	56,62	0
Woodland *E. eximia-E. gummifera-E. punctata*	2	10,15	20,52	8,25	325,500	30,40	0

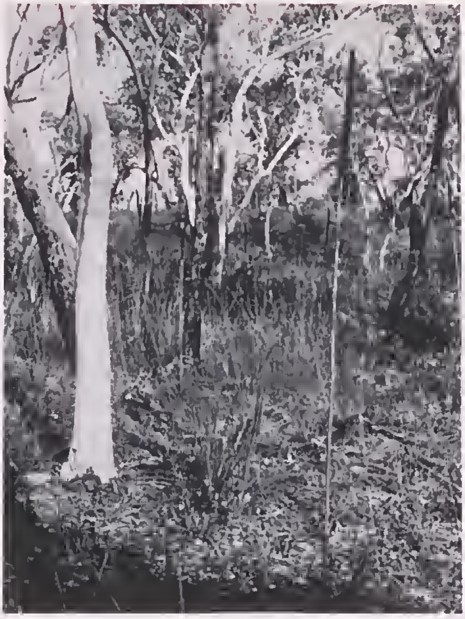


Figure 6. *Eucalyptus eximia-E. gummifera-E. punctata* woodland showing *E. racemosa* and *E. gummifera* with *Xanthorrhoea media.*

The main tree species are *Angophora costata* (Smooth-barked Apple) and *Eucalyptus piperita* subsp. *piperita* (Sydney Peppermint), though in moist gullies *Syncarpia glomulifera* (Turpentine) is frequent. Small trees of *Casuarina torulosa* and *Acacia elata* are often present. The characteristic understorey is a mid-dense to open layer of shrubs less than 1 m high together with ferns, predominantly *Pteridium esculentum.* Common shrub species are *Acacia ulicifolia, Platysace linearifolia, Oxylobium ilicifolium, Pultenaea flexilis* and *Persoonia linearis. Doryanthes excelsa* (Gymea Lily) may be locally abundant.

Boundaries are generally abrupt with *Eucalyptus tereticornis-E. eugenioides* open-forest and transitional or abrupt with *Eucalyptus eximia-E. gummifera-E. punctata* woodland.

The *Angophora costata-E. piperita* open-forest is essentially undisturbed though there has been some localized logging of larger trees, particularly *Syncarpia glomulifera.* The community is widespread on sandstone country around Sydney. Examples are preserved in Dharug National Park.

Eucalyptus eximia-Eucalyptus gummifera-Eucalyptus punctata WOODLAND

This community ranges in height from about 8 to 16 m and in density from woodland to open-forest, varying with exposure. It is confined to Hawkesbury Sandstone ridges and plateaux, on exposed, principally northerly and westerly, aspects.

Tree species vary with changes in aspect, slope and soil depth. Common species are *Eucalyptus gummifera* (Red Bloodwood), *E. eximia* (Yellow Bloodwood), *E. oblonga* (Narrow-leaved Stringybark), *E. punctata* (Grey Gum), *E. racemosa* (Scribbly Gum) and *Angophora bakeri* (Narrow-leaved Apple). The understorey is mid-dense to open with sclerophyllous shrubs up to 1 m high. Typical species are *Banksia aspleniifolia, Leptospermum attenuatum, Phyllota phylicoides, Lambertia formosa* and *Acacia ulicifolia.*

Boundaries with the adjacent *Angophora costata-E. piperita* open-forest are transitional or abrupt.

The community is not very disturbed, since it is restricted to poor soils which are little used agriculturally. It is widespread over much of the sandstone plateau area around Sydney. Good examples have been preserved in adjacent Dharug National Park.

Structure and floristics

Structural and species richness data for the four communities are presented in Table 2. Canopy height ranges from 10 to 25 m, mainly along a gradient related to exposure, i.e. from exposed ridgetop to sheltered gully. Projected foliage cover for almost all sites, except one in woodland was within the Mid-Dense (30–70%) category of Specht (1970). Basal area figures for all sites, except the woodland site were scattered between 20 and 50 m^2/ha, the ranges of different communities overlapping. Greatest basal area was in *A. costata-E. piperita* open-forest, a community that has been less severely logged or disturbed than the tall open-forest and other open-forest communities, which generally have a high number of small, even-sized trees or coppice regrowth. Disturbance in these latter two communities is indicated by the high stem density and low mean stem diameter figures.

Total number of species/site was lower for the woodland than the other communities, the sites in the former showing evidence of more recent fire than those in the forest communities, though all sites, except two in tall open-forest, showed signs of past burning. Although all sites were selected as being the least disturbed in a particular area, exotic species were recorded only in the tall open-forest and *E. tereticornis-E. eugenioides* open-forest. This may be due in part to the greater disturbance these communities have suffered, but may also be due to the unsuitability to exotics of the habitats on unmodified Hawkesbury Sandstone soils, even when disturbed.

TABLE 3

Czechanowski similarity coefficients for community pairs calculated from the total species lists for each community

Plant community	*E. tereticornis-E. eugenioides* Open-forest	*A. costata-E. piperita* Open-forest	*E. eximia-E. gummifera-E. punctata* Woodland
Eucalyptus deanei-Angophora floribunda Tall open-forest	0.63	0.35	0.17
Eucalyptus tereticornis-E. eugenioides Open-forest	..	0.38	0.19
Angophora costata-Eucalyptus piperita Open-forest	..	..	0.39

Floristic differences between the communities on the two major geological units are indicated (Table 3) by the Czechanowski similarity coefficients (Clifford & Stephenson, 1975). As sites sampled were chosen as representative of each community, similarity coefficients were not calculated for all site pairs but only from the total species lists for each community. The two communities on Narrabeen Group geology, *Eucalyptus deanei-Angophora floribunda* tall open-forest and *E. tereticornis-E. eugenioides* open-forest are most similar to one another and least similar to the *E. eximia-E. gummifera-E. punctata* woodland on Hawkesbury Sandstone. The *Angophora costata-E. piperita* open-forest is intermediate between the woodland and the Narrabeen Group communities.

TABLE 4

Comparison of plant communities from Mangrove Creek with those of Pidgeon, Specht et al. and Baur.

Plant community	Pidgeon (1937)	Specht et al. (1974)	Baur (1965)
Eucalyptus deanei-Angophora floribunda Tall open-forest	*Eucalyptus saligna-E. pilularis* Association	Tall open-forest *E. saligna-E. resinifera-E. pilularis*	Forest Type 52. Round leaved Gum-Turpentine
Eucalyptus tereticornis-E. eugenioides Open-forest	*Eucalyptus saligna-E. pilularis* Association	Open-forest *E. acmenoides-E. propinqua-E. microcorys*	Forest Type 64. Grey Gum-Stringybark
Angophora costata-Eucalyptus piperita Open-forest	Mixed *Eucalyptus* Forest Association	Open-forest Sandstone Complex	Forest Type 106. Smooth barked Apple-Sydney Peppermint-Stringybark
Eucalyptus eximia-E. gummifera-E. punctata Woodland	Mixed *Eucalyptus* Forest Association	Open-forest Sandstone Complex	Forest Type 100. Yellow Bloodwood

Although no attempt was made to record all species present in the area, an idea of the total flora to be expected may be estimated from a comparison with the adjacent Dharug National Park, an area of similar size. Here Matthew (1973), in three years of botanical exploration, recorded 514 native plant species. In Mangrove Creek only 196 species have been listed, including six exotic species, and it is reasonable to believe that a list of similar size to Matthew's could be compiled.

Classification of communities

Comparisons between the plant communities described for Mangrove Creek and relevant communities described by other workers are shown in Table 4. Pidgeon (1937) described two Associations for the area, while Specht *et al.* (1974) probably largely based on Pidgeon, described three. Pidgeon (1940), however, suggested that her Associations could be subdivided into "forest types", each of which would have a similar floristic composition of dominants and develop in essentially similar habitats. She did not, however, suggest any "forest types" for the Mangrove Creek area. The four communities recognized in the present survey are essentially "forest types" though each probably contains more habitat variation than she would have intended. Baur's (1965) "Forest Types" are similarly defined and types can be correlated with each of the communities recognized for Mangrove Creek.

However, although this level of classification was satisfactory for descriptive work, it was unsatisfactory for mapping. This is due mainly to the particular topography of the dissected sandstone plateaux, features of which are narrow, linear units along creek and gullies, and marked aspect differences, making up a recurring mosaic of communities often with intergradation between them. For mapping, medium-scale colour aerial photography and a 1:25 000 scale topographic base map were used, but only structural vegetation units could be consistently recognized (Table 1) and even then the differentiation between some of these (tall open-forest and open-forest) was unsatisfactory. It appears that although forest types are recognizable on Hawkesbury Sandstone, it is very difficult to map units within structural formations, except where these can be related to topographic or geological factors, which are otherwise evident in aerial photography. Similar results are indicated by J. S. Benson and Fallding (1979) who mapped Hawkesbury Sandstone areas in Brisbane Water National Park, about 20 km south-east of Mangrove Creek. Dealing with a more varied area, both floristically and structurally, ranging from closed-forest to sedgeland, they mapped (at scale 1:25 000) 18 communities, almost all recognized on structure with some subdivisions related to topographic position.

Forest types on Hawkesbury Sandstone are therefore probably best treated as components of a vegetation gradient associated with slope, soil depth, aspect etc. Austin (1978), in dealing with the sclerophyll forest communities of the South Coast of New South Wales, successfully grouped his forest communities into "types" on the basis of toposequences and altitudinal range. Using a similar approach at Mangrove Creek one would also take into consideration the major geological units present, as these are associated with important floristic differences. Thus a *Eucalyptus tereticornis-E. deanei-Angophora floribunda* toposequence type could be recognized on Narrabeen Group shales and sandstones, and a *E. eximia-E. punctata-Angophora costata* type on Hawkesbury Sandstone. Such types may need to be modified or extended when applied to areas with greater topographic variation than Mangrove Creek. For instance, on Hawkesbury Sandstone in the vicinity of the Colo River a possible toposequence-type would be *E. eximia-E. punctata-Angophora costata-E. saligna.*

Once toposequence types have been established, the relationships between vegetation structure, floristic composition and various gradients within these types can be studied in greater detail.

ACKNOWLEDGMENTS

The survey was undertaken at the request of the New South Wales Department of Public Works for information on the native vegetation which would be affected by the proposed Gosford-Wyong Water Supply Scheme. I wish to thank Mrs Helen Bryant for her help in collecting the data and preparing the diagrams and map, and my colleagues at the National Herbarium of New South Wales for help with the identification of specimens and comments on the manuscript.

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APPENDIX 1: SITE LOCATIONS

Eucalyptus deanei-Angophora floribunda Tall open-forest

Site 1—	33° 11′ S,	151° 07′ E
Site 2—	33° 12′ S,	151° 07′ E
Site 3—	33° 09′ S,	151° 07′ E

Eucalyptus tereticornis-E. eugenioides Open-forest

Site 4—	33° 11′ S,	151° 07′ E
Site 5—	33° 09′ S,	151° 06′ E
Site 6—	33° 12′ S,	151° 07′ E

Angophora costata-Eucalyptus piperita Open-forest

Site 7—	33° 12′ S,	151° 07′ E
Site 8—	33° 12′ S,	151° 10′ E

Eucalyptus eximia-E. gummifera-E. punctata Woodland

Site 9—	33° 12′ S,	151° 11′ E
Site 10—	33° 09′ S,	151° 07′ E

APPENDIX 2: SPECIES RECORDED FROM 20 x 20 m SITES

? = identification uncertain
x = present
C = common
* = exotic species

Nomenclature follows that currently used at the National Herbarium of New South Wales. Authorities are given in Beadle et al. (1972) except as follows:

Conyza albida Willd. ex Spreng.
C. canadensis (L.) Cronquist
Gonocarpus tetragynus Labill.
G. teucrioides DC.
Petrophile pulchella (Schrad.) R. Br.
Stylidium productum M. Hindmarsh et D. Blaxell

Eucalyptus and *Angophora* codings follow Pryor & Johnson (1971).

Botanical name	Sites									
	1	2	3	4	5	6	7	8	9	10
PTERIDOPHYTES										
Adiantaceae										
Adiantum aethiopicum	C	x	C	..	C	..	..	..	..	..
A. hispidulum	..	x	..	..	..	..	..	..	..	..
Cheilanthes tenuifolia	x	x	..	x	x	x	..	..	..	..
Pellaea falcata	..	..	..	..	x	..	..	..	..	..
Blechnaceae										
Blechnum cartilagineum	..	..	x	..	..	..	..	..	..	..
Doodia aspera	..	x	C	..	..	..	..	..	..	..
Cyatheaceae										
Culcita dubia	..	x	..	..	..	..	x	x	..	..
Dennstaedtiaceae										
Pteridium esculentum	C	C	C	C	..	..	x	C	..	..
Schizaeaceae										
Schizaea dichotoma	..	..	..	..	..	..	x	..	x	..

Botanical name	Sites									
	1	2	3	4	5	6	7	8	9	10
ANGIOSPERMS										
DICOTYLEDONS										
Acanthaceae										
Brunoniella pumilio	..	..	..	..	..	..	..	x	..	..
Pseuderanthemum variabile	..	..	x	..	x	..	..	..	..	..
Apiaceae										
Actinotus helianthi	..	..	..	..	..	..	..	..	..	x
A. minor	..	..	..	..	..	..	..	..	x	..
Centella asiatica	x	..	..	..	..	..	..	..	..	..
Hydrocotyle ? acutiloba	x	..	..	..	..	..	..	..	..	..
H. tripartita	..	..	x	..	x	..	..	..	..	..
Platysace linearifolia	..	..	..	..	..	x	C	x	x	x
Araliaceae										
Astrotricha floccosa	..	x	..	..	x	..	..	x	..	..
Polyscias sambucifolius	x	x	x	..	x	..	..	x	..	..
Asteraceae										
Cassinia aculeata	..	..	x	..	x	..	..	..	..	..
C. ? uncata	..	..	..	..	..	..	x	..	..	..
**Conyza albida*	..	..	x	..	x	x	..	x	..	..
**C. canadensis*	..	x	..	..	..	..	..	..	..	..
Gnaphalium japonicum s. lat.	x	x	..	..	..	..	..	..	..	..
Helichrysum diosmifolium	..	x	x	..	x	x	x	x	..	..
**Hypochoeris radicata*	x	x	x	x	x	x	..	..	..	..
Lagenifera stipitata	x	..	..	x	..	x	..	x	..	..
Senecio hispidulus	x	..	..	..	..	..	..	..	..	..
S. lautus	x	x	..	..	..	..	..	..	..	..
Sigesbeckia orientalis	x	x	..	..	..	..	..	..	..	..
Campanulaceae										
Wahlenbergia communis	..	..	..	..	..	x	..	..	..	..
W. stricta	x	..	..	..	..	..	..	..	..	..
Casuarinaceae										
Casuarina torulosa	..	..	x	..	..	x	x	x	..	..
Celastraceae										
Maytenus silvestris	..	..	x	..	x	..	..	..	..	..
Convolvulaceae										
Dichondra repens	..	x	C	..	x	..	..	..	..	..
Polymeria calycina	..	..	..	..	..	..	..	x	..	..
Crassulaceae										
Crassula sieberana	x	..	x	..	x	..	..	..	..	..
Cunoniaceae										
Ceratopetalum gummiferum	..	..	..	..	..	..	x	..	..	..
Dilleniaceae										
Hibbertia diffusa	..	..	..	x	..	..	..	..	..	..
H. empetrifolia	..	..	..	..	..	..	..	x	..	..
H. scandens	x	C	C	..	C	..	..	x	..	..
Droseraceae										
Drosera sp.	..	..	..	..	..	..	x	..	..	..
Elaeocarpaceae										
Elaeocarpus reticulatus	..	..	..	..	..	..	x	..	..	..
Epacridaceae										
Epacris pulchella	..	..	..	..	..	..	..	..	x	..
Leucopogon lanceolatus	..	..	x	..	..	..	x	..	..	..
L. muticus	..	..	..	..	..	..	..	x	..	x
Melichrus procumbens	..	..	..	..	..	..	..	..	..	x
Monotoca scoparia	..	..	..	..	..	..	x	..	x	x
Trochocarpa laurina	..	..	..	..	..	..	..	x	..	..
Euphorbiaceae										
Amperea xiphoclada	..	..	..	..	..	..	..	x	..	..
Breynia oblongifolia	x	x	..	x	x	x	..	x	..	..
Phyllanthus thymoides	..	..	..	x	..	x	x	..	x	x
Poranthera microphylla	..	..	..	..	..	x	..	..	..	..

Botanical name	Sites									
	1	2	3	4	5	6	7	8	9	10
Fabaceae										
Bossiaea heterophylla	..	..	..	..	..	..	x	..	..	x
Daviesia acicularis	..	..	..	..	..	..	..	..	..	x
D. ulicifolia	x	..	..	x	..	x	x	..	x	..
Desmodium rhytidophyllum	..	x	..	x	..	x	..	..	..	..
D. varians	C	..	..	..	..	..	x	..	..	..
Dillwynia retorta	..	..	..	..	..	..	..	..	..	x
Glycine spp.	x	x	x	x	x	x	..	x	..	..
Gompholobium latifolium	..	..	..	..	..	..	x	..	..	..
Hardenbergia violacea	x	..	..	x	..	..	x	x	..	C
Hovea linearis	..	..	..	..	..	..	x	..	..	..
Indigofera australis	..	x	..	..	..	..	..	..	x	..
Jacksonia scoparia	..	..	..	x	..	x	..	..	..	..
Kennedia rubicunda	x	..	x	..	..	..	..	x	..	..
Oxylobium ilicifolium	x	..	x	C	..	x	C	C	..	x
Pultenaea flexilis	..	..	..	..	..	..	x	..	..	..
Pultenaea scabra	..	..	..	..	..	..	..	..	..	x
Gentianaceae										
Centaurium sp.	..	..	..	..	x	..	..	..	..	..
Geraniaceae										
Geranium sp.	..	..	x	..	x	..	..	..	..	..
Pelargonium sp.	x	..	C	..	x	..	..	..	..	..
Goodeniaceae										
Goodenia heterophylla	x	..	..	x	..	x	..	x	..	..
Scaevola ramosissima	..	..	..	..	..	..	..	..	x	..
Haloragaceae										
Gonocarpus tetragynus	x	..	..	x	..	..	x	..	..	x
G. teucrioides	..	..	x	..	..	..	..	..	..	..
Hypericaceae										
Hypericum sp.	..	..	x	..	..	..	..	..	..	..
Lamiaceae										
Plectranthus parviflorus	..	..	x	..	x	..	..	..	..	..
Prostanthera ? ovalifolia	..	x	x	..	..	..	..	..	..	..
Lobeliaceae										
Lobelia sp.	..	..	..	..	..	..	..	x	..	..
Pratia purpurascens	x	C	x	x	x	x	..	..	..	..
Menispermaceae										
Sarcopetalum harveyanum	..	..	x	..	..	..	..	..	..	..
Stephania japonica	..	x	..	..	..	..	..	..	..	..
Mimosaceae										
Acacia buxifolia	..	..	..	..	..	..	x	..	..	..
A. elata	..	..	..	..	..	..	..	x	..	..
A. filicifolia	x	x	..	..	x	x	..	..	..	..
A. implexa	..	..	..	..	..	x	..	..	..	..
A. linifolia	..	..	..	..	..	..	..	..	..	x
A. longifolia	..	..	..	..	..	..	x	..	..	..
A. suaveolens	..	..	..	..	..	..	x	x	x	..
A. ulicifolia	..	..	..	..	..	..	C	C	..	C
Myrsinaceae										
Rapanea variabilis	..	..	x	..	x	..	..	x	..	..
Myrtaceae*										
Acmena smithii	..	..	x	..	..	..	..	..	..	..
Angophora bakeri AAABD	..	..	..	..	..	..	..	..	..	x
A. costata AAADA	..	..	..	..	..	..	x	x	..	..
A. floribunda AAABB	x	..	..	..	x	x	..	..	..	..
Backhousia myrtifolia	..	x	x	..	x	..	..	..	..	..
Eucalyptus acmenoides MAG:C	x	..	..	x	..	x	..	..	..	..
E. crebra SUP:S	..	..	..	..	x	..	..	..	..	..
E. deanei SECAA	C	C	C	x	x	..	..	..	..	..
E. eugenioides MAHEA	x	x	x	C	C	..	..	..	..	..
E. gummifera CAFUF	..	..	..	..	..	..	..	C	x	..
E. piperita subsp. *piperita* MATHAA	..	..	..	..	..	..	x	..	..	..

* *Eucalyptus eximia* CCA:E although a characteristic species for the relevant community, was not present in sample sites 9 and 10.

Botanical name	Sites									
	1	2	3	4	5	6	7	8	9	10
Myrtaceae—*continued*										
E. punctata SECED	..	..	..	C	..	x	..	..	..	..
E. racemosa MATKE	..	..	..	..	..	..	..	..	x	..
E. tereticornis SNEEB	..	..	..	..	C	..	..	..	..	..
E. umbra subsp. *umbra* MAG: AA	..	..	..	..	..	..	x	..	..	..
E. sp. nov. MAHEK	..	..	..	..	..	..	..	..	..	x
Leptospermum attenuatum	..	..	..	..	..	..	x	..	C	C
L. flavescens	..	C	x	..	..	..	..	..	..	..
Syncarpia glomulifera	..	..	..	..	..	..	C	x	..	..
Tristania laurina	..	..	..	..	..	..	x	..	..	..
Oleaceae										
Notelaea longifolia	..	..	x	..	..	..	..	..	..	..
Oxalidaceae										
Oxalis corniculata	..	x	..	x	x	x	..	..	..	..
Pittosporaceae										
Billardiera scandens	..	x	..	x	x	x	..	x	..	x
Bursaria spinosa	..	x	..	..	..	..	..	..	..	..
Plantaginaceae										
Plantago debilis	x	x	..	..	x	..	..	..	..	..
Polygonaceae										
Muehlenbeckia ? gracillima	..	x	..	..	..	..	..	..	..	..
Primulaceae										
**Anagallis arvensis*	..	x	x	..	..	..	..	..	..	..
Proteaceae										
Banksia aspleniifolia	..	..	..	..	..	..	..	..	x	..
B. serrata	..	..	..	..	..	..	x	..	x	..
Conospermum longifolium	..	..	..	..	..	..	..	..	x	..
Grevillea linearifolia	..	..	..	..	..	..	..	x	..	..
Hakea sericea	..	..	..	..	..	..	..	..	x	..
Isopogon anemonifolius	..	..	..	..	..	..	..	..	x	..
Lambertia formosa	..	..	..	..	..	..	..	..	x	C
Lomatia silaifolia	..	..	..	..	..	..	..	x	x	x
Persoonia laurina	..	..	..	..	..	..	..	..	x	..
P. levis	..	..	..	..	..	..	x	..	..	..
P. linearis	x	x	..	x	x	x	x	x	..	x
Petrophile pulchella	..	..	..	..	..	..	..	..	x	..
Telopea speciosissima	..	..	..	..	..	..	C	..	..	..
Xylomelum pyriforme	..	..	..	..	..	..	x	x	..	..
Ranunculaceae										
Clematis aristata	x	x	x	..	x	..	..	x	..	..
Ranunculus lappaceus	x	x	..	..	x	..	..	..	..	..
Rosaceae										
**Rubus discolor*	..	..	..	..	x	..	..	..	..	..
R. parvifolius	..	x	x	..	x	..	..	..	..	..
Rubiaceae										
Galium propinquum	..	..	..	..	x	..	..	..	..	..
Opercularia varia	..	..	..	..	x	..	..	..	..	..
Pomax umbellata	..	..	..	x	..	x	x	x	..	x
Rutaceae										
Euodia micrococca	..	..	x	..	..	..	..	..	..	..
Santalaceae										
Exocarpos strictus	..	..	x	x	..	..	..	..	..	..
Sapindaceae										
Dodonaea triquetra	..	x	..	..	x	..	..	x	..	..
Scrophulariaceae										
Veronica plebeia	x	..	x	..	..	x	..	x	..	..
Solanaceae										
Duboisia myoporoides	..	x	x	x	x	x	..	..	..	..
Solanum prinophyllum	..	..	x	..	..	..	..	..	..	..
Solanum sp.	..	..	..	..	..	..	..	x	..	..
Stylidiaceae										
Stylidium productum	..	..	..	..	..	..	x	..	..	..

Botanical name	Sites 1	2	3	4	5	6	7	8	9	10
Thymelaeaceae										
Pimelea latifolia subsp. *C*	..	..	..	..	..	..	..	x	..	..
P. linifolia	..	..	..	..	..	..	x	..	..	C
Ulmaceae										
Trema aspera	..	x	..	..	..	..	..	..	..	..
Verbenaceae										
**Verbena* sp.	..	..	x	..	x	..	..	..	..	..
Vitaceae										
Cayratia clematidea	..	x	x	..	x	..	..	..	..	..
MONOCOTYLEDONS										
Araceae										
Gymnostachys anceps	..	..	x	..	..	..	..	..	..	..
Commelinaceae										
Commelina cyanea	..	..	..	..	x	..	..	..	..	..
Cyperaceae										
Carex appressa	..	x	..	..	..	..	..	..	..	..
Caustis flexuosa	..	..	..	..	..	..	..	..	..	x
Cyathochaeta diandra	..	..	..	..	..	..	..	x	..	..
Cyperus laevis	..	x	..	x	..	..	..	..	..	..
Gahnia aspera	..	..	..	..	x	..	..	..	..	..
Lepidosperma laterale	x	x	..	..	..	..	..	..	..	x
Ptilanthelium deustum	..	..	..	..	..	..	..	..	x	..
Dioscoreaceae										
Dioscorea transversa	..	..	..	..	..	..	..	x	..	..
Haemodoraceae										
Haemodorum corymbosum	..	..	..	..	..	..	..	x	..	x
Hypoxidaceae										
Hypoxis hygrometrica	x	x	..	..	..	..	..	..	..	..
Iridaceae										
Patersonia glabrata	..	..	..	..	..	..	x	..	..	..
P. sericea	..	..	..	..	..	..	..	..	x	..
Liliaceae										
Arthropodium milleflorum	x	..	..	x	..	..	..	..	..	..
Dianella caerulea	x	..	..	x	..	..	x	x	..	x
D. laevis	..	..	..	x	..	x	..	..	..	..
D. revoluta	..	..	..	..	..	x	..	..	x	x
Orchidaceae										
Acianthus sp.	..	..	..	..	..	..	x	..	..	x
Lyperanthes suaveolens	..	..	..	..	..	..	..	..	..	x
Pterostylis curta	..	..	x	..	x	..	..	..	..	..
Philesiaceae										
Eustrephus latifolius	x	x	x	..	..	..	..	..	..	..
Geitonoplesium cymosum	..	x	x	..	..	..	..	x	..	..
Poaceae										
Aristida vagans	..	..	..	x	..	x	..	..	..	..
Dichelachne micrantha	..	..	..	x	..	x	..	..	..	..
Digitaria sp.	..	..	..	..	..	x	x	x	..	..
Echinopogon caespitosus	x	..	..	x	..	x	..	..	..	..
Entolasia marginata	..	..	..	..	..	..	..	..	x	..
E. stricta	x	..	..	x	..	..	x	..	..	x
Eragrostis brownii	..	..	..	..	..	x	x	..	..	..
Imperata cylindrica	C	..	x	..	x	..	..	..	..	x
Microlaena stipoides	x	..	..	..	..	x	..	..	..	..
Oplismenus aemulus	..	C	C	x	x	..	..	x	..	..
Panicum simile	x	..	..	..	..	x	..	..	..	..
Paspalidium radiatum	..	..	..	..	..	..	..	x	..	..
Themeda australis	..	..	..	x	..	x	..	..	..	..
Xanthorrhoeaceae										
Lomandra cylindrica	..	..	..	..	..	..	..	..	x	..
L. filiformis	..	..	..	x	..	x	x	x	..	x
L. glauca	..	..	..	..	..	..	..	..	x	x
L. gracilis	..	..	x	..	..	..	x	..	..	x
L. longifolia	x	x	x	..	x	..	..	x	..	..
L. obliqua	..	..	..	..	..	x	x	..	x	x
Xanthorrhoea media subsp. *media*	..	..	..	..	..	..	C	..	C	x

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THE VASCULAR PLANTS OF FIVE EXCLOSURE SITES IN WESTERN NEW SOUTH WALES

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ABSTRACT

Cunningham, G. M. & Milthorpe, P. L. (Soil Conservation Service of New South Wales, Condobolin, New South Wales, Australia 2877) 1981. *The vascular plants of five exclosure sites in western New South Wales. Cunninghamia* 1 (1): 23–34. A list of 401 species representing 61 families and 91 genera was recorded from five exclosure sites in semiarid western New South Wales. Any plants that could not be identified by the authors in the field were collected and determined at the National Herbarium of New South Wales. Duplicates of these specimens are housed at the Soil Conservation Office at Condobolin. Fifty-five naturalized species, mainly from the families Poaceae, Asteraceae, Fabaceae and Brassicaceae, were recorded. Several native species that are rare in the region were also found in the exclosures. A brief description of the exclosure sites is presented.

INTRODUCTION

Soil conservation in the arid and semiarid sections of New South Wales is vitally linked with rangeland management. Proper range management is dependent on a thorough knowledge of the vegetation as well as an understanding of the changes which occur with grazing, exlcosure or other management manipulations. Although the arid and semiarid rangelands of western New South Wales have been grazed for between 110 and 140 years there has been very little formalization of range management.

During the early 1950's the Soil Conservation Service of New South Wales set up a series of exclosures at sites adjacent to the transcontinental railway line between Condobolin and the Darling River in western New South Wales. An additional exclosure was fenced at Cobar in 1963 as a site for revegetation trials.

These exclosures were originally established to study erosion and natural reclamation as well as to evaluate reclamation techniques and for ecological studies. The areas represent some of the more erosion susceptible land types in western New South Wales. As well as meeting these stated needs, the exclosures have, over the years, provided sites for botanical collection to determine the richness of the species assemblage within the different vegetation communities under conditions where domestic livestock grazing was excluded. Details of the size, location, year established, soils and vegetation communities of these exclosures are contained in Table 1 and their location can be seen in Figure 1.

We know little of the species which comprise each vegetation community under grazing, let alone prior to grazing. However, Beadle (1948) attempted to list the species which occurred in the major vegetation communities.

While it may never be possible nor desirable to return to the pre-domestic grazing situation, since there have doubtless been many irreversible soil and vegetation changes, there is much value in recording the present species assemblage to provide a reference point for the future.

The list (Table 2) presented here is an initial attempt to describe the species assemblage at each site in the hope that it will provide a basis for future ecological studies of these communities.

TABLE 1

Details of the five exclosures

Exclosure	Year fenced	Mean annual rainfall (mm)	Location	Area (ha)	Topography, soils	Vegetation
Cobar	1963	360	11 km south of Cobar 145° 53′ E, 31° 35′ S	81	Undulating (to 3% slope) gravelly ridges; uniform (skeletal) and gradational (red earth) soils.	Open woodland of mulga (*Acacia aneura*) ironwood (*Acacia excelsa*), bimble box (*Eucalyptus populnea*), red box (*Eucalyptus intertexta*) and white cypress pine (*Callitris columellaris*). Clumps of shrubs (mainly *Eremophila spp.*) and white cypress pine regrowth.
Booberoi	1950	380	64 km west of Condobolin on Booberoi Station 146° 30′ E, 33° 02′ S	120	Generally level red brown earths; small gravelly rise; large areas of scald and reclaimed scald.	Open grassland, few bimble box (*Eucalyptus populnea*), white cypress pine (*Callitris columellaris*), yarran (*Acacia homalophylla*). Dense regeneration of white cypress pine on some sections.
Micabil	1952	410	21 km west of Condobolin 146° 57′ E, 33° 05′ S	12	Level to slightly undulating (1% slope) scalded clay surfaces; salt crusted heavy grey clays; scalded level to slightly undulating duplex soils with exposed smooth and gravelly scalds.	Initially completely bare. Now substantially covered by a dense bladder saltbush (*Atriplex vesicaria*) and old man saltbush (*A. nummularia*) community.
Sayers Lake	1952	230	88 km west of Ivanhoe and 2 km west of Manara railway siding. 143° 24′ E, 32° 48′ S	421	Slightly undulating (to 2% slope); generally sandy surfaced soils with either duplex red brown earth or gradational profiles. Some severe scald and reclaimed scald.	Black bluebush (*Maireana pyramidata*) and bladder saltbush (*Atriplex vesicaria*) communities with belah (*Casuarina cristata*), rosewood (*Heterodendrum oleifolium*) and nelia (*Acacia loderi*) clumps.
Trida	1950	320	9 km west of Trida railway siding. 144° 56′ E, 33° 00′ S	567	Generally level heavy grey self-mulching clays; firm, compact grey and brown clays and scalded duplex soils.	Open bladder saltbush (*Atriplex vesicaria*) plains with cotton bush (*Maireana aphylla*), lignum (*Muehlenbeckia cunninghamii*), and nitre goosefoot (*Chenopodium nitrariaceum*) communities. Clumps of swamp box (*Eucalyptus largiflorens*).

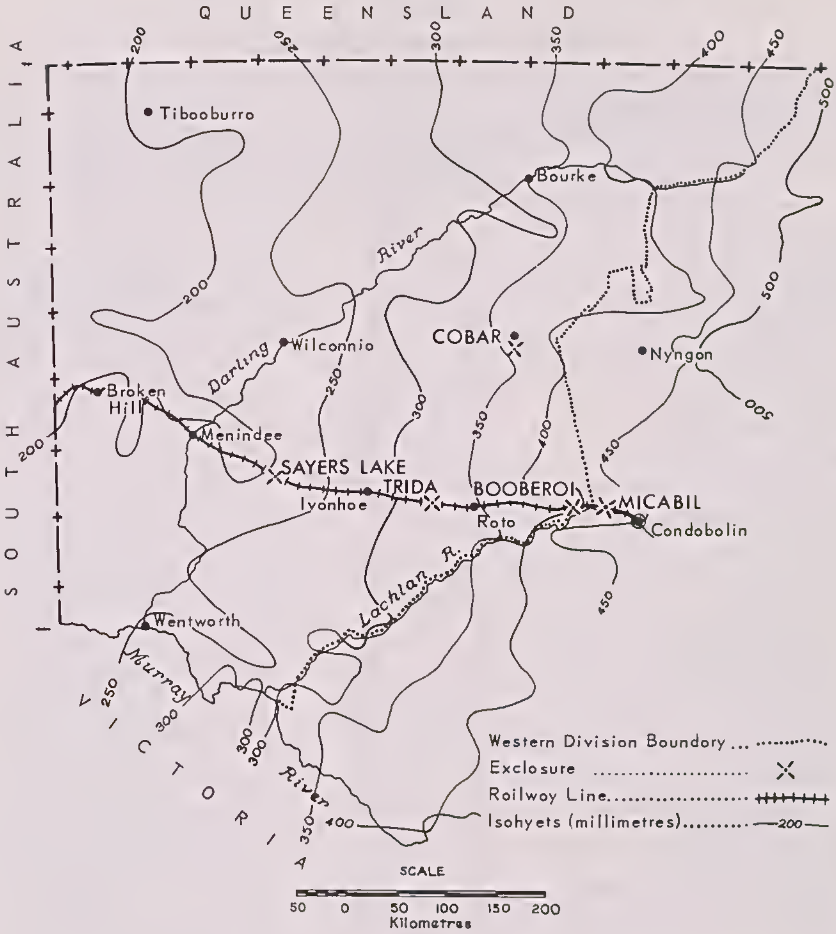

Figure 1. The western half of New South Wales showing the location of the five exclosures and the rainfall isohyets.

THE LIST AND ITS ARRANGEMENT

Most of the specimens at each exclosure were identified in the field but unusual specimens were sent to the National Herbarium for identification. Obviously there are disadvantages in not having voucher specimens to verify all identifications but the time involved in collecting easily recognisable species and having them identified, combined with the problems of specimen mounting and storage, dictated against collecting voucher specimens when positive field identification was possible.

Collection of data was carried out at the Cobar site between 1963 and 1976, while all other areas were visited between 1973 and 1976. Most collections were made in spring, although some visits were made at other times. We do not, however, claim that our collections at each site are exhaustive.

For convenience of reference, species are shown in alphabetical order within families, which are in turn arranged alphabetically. The family, generic and specific names are those currently in use at the New South Wales National Herbarium. Exotic species, marked with an asterisk (*), have been included only when they have been naturalized in the area and are capable of reproduction and persistence in the natural environment.

TABLE 2

Species recorded at the five exclosures

* = introduced species.
x = species identified from exclosure.

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
PTERIDOPHYTES					
Marsileaceae					
Marsilea drummondii	..	..	x	x	x
Ophioglossaceae					
Ophioglossum lusitanicum subsp. *coriaceum*	..	x	..	..	..
Polypodiaceae					
Cheilanthes tenuifolia	x	x	x	..	..
GYMNOSPERMS					
Cupressaceae					
Callitris columellaris	x	x	..	..	..
ANGIOSPERMS					
DICOTYLEDONS					
Aizoaceae					
Tetragonia eremaea	..	..	..	x	..
T. tetragonioides	..	..	..	x	x
Zaleya galericulata	x	..	..	..	..
Amaranthaceae					
Alternanthera augustifolia	x	..	..	..	x
A. denticulata	x	..	..	x	..
A. nodiflora	..	..	..	x	..
Amaranthus macrocarpus	..	..	..	..	x
A. sp. (undescribed)	..	x	..	..	..
Ptilotus atriplicifolius	..	x	..	..	..
P. exaltatus	..	x	..	..	..
P. gaudichaudii var. *parviflorus*	..	x	..	..	..
P. nobilis	..	..	..	..	x
P. obovatus	x	x	..	x	..
Apiaceae					
Daucus glochidiatus	x	x	x	x	x
Asteraceae					
Actinobole uliginosum	x	x	..	..	..
Angianthus strictus	x	..	..	..	..
A. tomentosus	..	..	..	..	x
**Arctotheca calendula*	x	..	x	..	..
**Aster subulatus*	..	..	x	..	..
Brachycome ciliaris	..	..	x	x	..
B. goniocarpa	..	..	..	..	x
B. lineariloba	x	x	x	x	x
B. marginata	..	x	..	x	..
Calocephalus citreus	x	..	..	..	..
C. sonderi	..	..	x	..	x
Calotis cuneifolia	..	x	..	..	..
C. cymbacantha	..	..	..	x	..
C. hispidula	x	x	..	x	x
C. lappulacea	..	x	..	..	..
C. multicaulis	..	..	..	x	..
C. scabiosifolia var. *integrifolia*	..	..	..	x	..
C. scabiosifolia var. *scabiosifolia*	x	..	..	..	..
**Carthamus lanatus*	x	x	x	..	..
Cassinia laevis	..	x	..	..	..
**Centaurea melitensis*	x	x	..	x	x
Centipeda cunninghamii	..	x	..	..	x
C. minima	..	..	..	..	x
C. thespidioides	x	..	..	x	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
**Chondrilla juncea*	..	x	..	..	..
Chthonocephalus pseudevax	x	..	..	..	..
**Conyza bonariensis*	..	..	x	..	..
Craspedia chrysantha	..	..	..	..	x
C. pleiocephala	..	..	..	x	..
Eclipta platyglossa	..	..	x	..	..
Epaltes cunninghamii	..	..	..	x	..
Gnaphalium luteo-album	..	..	..	x	x
G. sphaericum	x	..	..	x	x
Gnaphalodes condensatum	..	x	..	..	..
Gnephosis foliata	..	..	..	..	x
**Hedypnois rhagadioloides* subsp. *cretica*	x	x	..	..	..
Helichrysum apiculatum	x	x	x	..	..
H. bracteatum	x	x	x	..	x
H. semipapposum	..	x	..	..	..
Helipterum australe	x	x	x	..	..
H. corymbiflorum	x	..	x	x	x
H. floribundum	x	x	..	x	x
H. moschatum	..	..	..	x	..
H. polygalifolium	..	..	..	x	..
H. pygmaeum	x	x	..	x	..
**Hypochaeris radicata*	x	x	x	..	..
Isoetopsis graminifolia	x	x	..	..	..
Ixiolaena leptolepis	..	..	..	x	x
I. tomentosa	..	..	..	..	x
**Lactuca serriola*	x	..	..	..	..
Leptorhynchos panaetioides	x	..	x	..	x
Minuria cunninghamii	x	..	x	x	x
M. denticulata	x	..	x	x	x
M. integerrima	..	..	..	x	x
M. leptophylla	x	x	..	..	..
Myriocephalus rhizocephalus	x	..	..	..	..
Olearia pimeleoides	..	x	..	..	..
Rutidosis helichrysoides	..	x	..	..	..
Senecio glossanthus	x	..	..	x	..
S. lautus	..	..	..	..	x
S. quadridentatus	..	x	..	..	..
S. runcinifolius	..	..	..	..	x
**Sonchus oleraceus*	x	x	x	x	x
Stuartina muelleri	x	..	..	..	..
Vittadinia sp. A	..	..	..	..	x
V. triloba	x	x	x	x	x
V. cuneata	..	x	..	..	..
Boraginaceae					
**Echium plantagineum*	x	x	x	x	x
Omphalolappula concava	..	..	..	x	..
Plagiobothrys plurisepaleus	x	..	..	..	..
Brassicaceae ..					
Arabidella sp. aff. *glaucescens*	..	x	..	..	..
A. trisecta	..	x	..	x	..
**Brassica tournefortii*	..	..	..	x	..
Cuphonotus humistratus	x	x	..	..	..
Lepidium fasciculatum	x	..	x	..	x
L. hyssopifolium	x	x	x	..	..
L. rotundum	..	..	..	x	..
L. sagittulatum	..	..	x	..	..
Phlegmatospermum cochlearinum	..	..	..	x	..
**Rapistrum rugosum*	..	..	..	x	..
**Sisymbrium altissimum*	x	..	..	..	..
**S. irio*	x	..	..	..	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
**S. monoplocoides*	x	..	..	..	..
**S. orientale*	..	x	x	..	x
Stenopetalum sp.	..	x	..	..	..
Caesalpiniaceae					
Cassia eremophila	x	x	..	x	..
C. helmsii/artemisioides (intergrading population)	..	..	..	x	..
C. phyllodinea	..	..	..	..	x
Campanulaceae					
Wahlenbergia communis	x	..	..	x	..
W. gracilis	..	..	x	..	..
W. sp. (undescribed)	x	..	..	..	..
W. sp. aff. *communis*	x	..	..	..	x
W. sp. (undescribed)	..	..	x	..	..
Capparidaceae					
Apophyllum anomalum	..	x	..	..	x
Capparis mitchellii	..	x	..	..	..
Caryophyllaceae					
Spergularia rubra sens. lat.	x	..	x	x	x
Casuarinaceae					
Casuarina cristata subsp. *pauper*	..	..	..	x	..
Chenopodiaceae					
Atriplex angulata	..	..	..	x	..
A. conduplicata	..	..	x	x	x
A. eardleyae	x	..	..	..	..
A. intermedia	..	..	..	x	..
A. leptocarpa	x	..	x	x	x
A. limbata	..	..	..	x	..
A. lindleyi	..	..	x	..	x
A. microcarpa	x	..	..	..	..
A. nummularia	..	..	x	..	x
A. pseudocampanulata	x	..	x	x	x
A. semibaccata	x	..	x	x	x
A. spinibractea	..	x	..	..	..
A. spongiosa	..	..	..	..	x
A. stipitata	..	x	..	x	..
A. vesicaria	..	..	x	x	x
Babbagia acroptera	..	..	x	x	x
Chenopodium anidiophyllum	..	x	..	..	..
C. carinatum	..	x	..	..	..
C. melanocarpum	x	..	x	..	..
**C. murale*	x	..	..	..	..
C. nitrariaceum	x	..	..	x	x
C. pseudomicrophyllum	..	x	..	..	..
Dissocarpus biflorus var. *biflorus*	..	..	x	..	x
D. biflorus var. *cephalocarpus*	..	..	..	x	..
D. paradoxus	..	..	..	x	..
Enchylaena tomentosa	x	x	..	x	x
Maireana aphylla	x	..	..	x	x
M. appressa	..	x	..	x	..
M. brevifolia	..	..	x	..	..
M. georgei	x	..	x	x	..
M. humillima	x	x	..	..	..
M. microphylla	..	..	x	..	..
M. pentagona	x	..	x	..	..
M. pyramidata	..	..	..	x	..
M. sclerolaenoides	x	..	..	x	..
M. tomentosa	..	x	..	x	..
M. triptera	..	x	..	..	..
M. villosa	..	x	..	..	..
Malacocera tricornis	..	..	x	x	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
Rhagodia nutans	..	x	..	..	x
R. spinescens	..	x	..	x	x
Salsola kali	x	x	x	x	x
Sclerolaena anisacanthoides	..	..	..	..	x
S. articulata	..	..	..	x	..
S. bicornis var. *bicornis*	..	..	..	..	x
S. bicornis var. *horrida*	..	..	..	..	x
S. birchii	..	..	..	x	..
S. calcarata	..	..	..	..	x
S. decurrens	..	..	..	x	..
S. diacantha	..	x	x	x	x
S. divaricata	..	..	..	x	x
S. eriacantha	..	..	..	x	..
S. intricata	..	..	..	..	x
S. intricata (3-spined form)	..	..	..	x	..
S. lanicuspis	..	..	..	x	x
S. muricata (4-spined form)	x	..	..	..	..
S. muricata var. *muricata*	..	..	x	x	x
S. muricata var. *villosa*	..	..	..	..	x
S. obliquicuspis	..	..	..	x	..
S. patenticuspis	..	..	..	x	..
S. tricuspis	..	..	x	..	..
S. uniflora	..	..	..	x	..
S. ventricosa	..	..	..	x	..
S. sp. B.	x	..	..	..	x
S. sp.	..	..	x	x	x
Sclerostegia tenuis	..	..	..	x	..
Threlkeldia salsuginosa	..	..	x	..	..
Convolvulaceae					
Convolvulus erubescens	x	x	x	x	x
Crassulaceae					
Crassula sieberana	..	x	x	x	..
Cucurbitaceae					
**Citrullus lanatus*	..	..	..	x	..
Euphorbiaceae					
Euphorbia drummondii	x	x	x	x	x
E. eremophila	..	..	..	..	x
Fabaceae					
Lotus cruentus	..	..	..	x	..
**Medicago laciniata*	x	x	..	..	..
**M. minima*	x	x	..	..	..
**M. polymorpha* var. *brevispina*	..	..	..	x	..
**M. polymorpha* var. *vulgaris*	x	x	x	x	x
**M. sativa*	..	..	x	..	..
**M. truncatula*	..	x	x	x	x
Swainsona burkittii	..	..	..	x	..
S. microphylla subsp. *affinis*	..	x	..	..	..
S. murrayana	..	..	..	..	x
S. procumbens	..	..	..	..	x
S. swainsonioides	..	..	..	..	x
**Trifolium arvense*	x	..	..	..	..
**T. glomeratum*	x	x	x	..	..
**T. tomentosum*	x	x	x	..	..
Trigonella suavissima	..	..	..	x	..
**Vicia monantha*	..	..	..	x	..
Frankeniaceae					
Frankenia crispa	..	..	..	x	..
F. serpyllifolia	..	..	..	..	x
Gentianaceae					
Centaurium spicatum	..	..	x	..	..
**C. tenuiflorum*	..	..	..	..	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
Geraniaceae					
Erodium crinitum	x	x	x	x	..
E. cygnorum subsp. *glandulosum*	..	..	..	x	x
Goodeniaceae					
Goodenia cycloptera	x	x	..	..	..
G. fascicularis	x	x	x	..	x
G. gracilis	..	..	..	..	x
G. heteromera	..	..	..	..	x
G. pinnatifida	..	x	..	x	..
G. pusilliflora	..	..	..	x	..
Scaevola aemula	..	x	..	..	..
Haloragaceae					
Haloragis glauca	..	..	..	x	..
H. heterophylla	..	..	..	x	..
Lamiaceae					
**Marrubium vulgare*	x	..	..	..	..
Teucrium racemosum	x	..	..	x	x
Linaceae					
Linum marginale	x	..	..	..	..
Lobeliaceae					
Pratia concolor	..	..	x	..	..
Loranthaceae					
Amyema quandang	..	x	..	..	..
Lysiana sp.	..	..	..	x	..
L. subfalcata	..	x	..	..	..
Lythraceae					
Lythrum hyssopifolia	..	..	x	..	x
Malvaceae					
Abutilon halophilum	..	..	..	..	x
A. otocarpum	..	x	..	..	..
Hibiscus brachysiphonius	x	..	..	..	..
Lavatera plebeia	..	..	..	x	x
**Malva parviflora*	..	..	x	..	x
Malvastrum americanum	..	..	..	x	x
Sida corrugata	x	..	..	x	..
S. cunninghami	x	x	..	..	..
S. fibulifera	..	x	..	..	x
S. intricata	..	..	..	x	..
S. trichopoda	x	..	..	..	x
Mimosaceae					
Acacia aneura	..	x	..	..	..
A. burkittii	..	x	..	..	..
A. excelsa	..	x	..	..	..
A. loderi	..	..	..	x	..
A. oswaldii	..	x	..	..	..
A. stenophylla	..	..	..	..	x
Myoporaceae					
Eremophila bignoniiflora	x	..	x	..	..
E. longifolia	..	x	..	x	x
E. mitchellii	x	x	..	..	..
E. sturtii	..	x	..	x	..
Myoporum deserti	..	x	..	..	..
M. platycarpum	..	..	..	x	..
Myrtaceae					
Eucalyptus intertexta	..	x	..	..	..
E. largiflorens	..	..	..	..	x
E. populnea	x	x	..	..	..
E. socialis	..	x	..	..	..
Oleaceae					
Jasminum lineare	..	x	..	..	..

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
Oxalidaceae					
Oxalis corniculata	x	x	x	x	x
Papaveraceae					
*_Argemone ochroleuca_ subsp. _ochroleuca_	..	x	..	..	..
Plantaginaceae					
Plantago cunninghamii	x	..	x	..	x
P. drummondii	..	..	..	x	x
P. turrifera	x	x	..	x	..
Pittosporaceae					
Pittosporum phillyreoides	..	x	..	..	..
Polygonaceae					
Muehlenbeckia cunninghamii	..	..	..	..	x
Rumex brownii	x	x	..	..	..
R. crystallinus	..	..	..	x	x
R. tenax	..	..	x	..	..
Portulacaceae					
Calandrinia balonensis	..	..	..	..	x
C. eremaea	x	..	x	x	..
_C._ sp.	..	..	..	x	..
Portulaca oleracea	..	x	x	..	x
Primulaceae					
*_Anagallis arvensis_	..	x	..	..	..
Proteaceae					
Hakea tephrosperma	x	x	..	..	..
Ranunculaceae					
Myosurus minimus	..	..	x	x	x
Ranunculus pentandrus var. _platycarpus_	x	..	..	x	..
Resedaceae					
*_Reseda luteola_	..	x	..	..	..
Rubiaceae					
Asperula cunninghamii	x	x	..	..	..
Canthium oleifolium	..	x	..	..	..
Rutaceae					
Geijera parviflora	x	x	..	..	..
Santalaceae					
Exocarpos aphyllus	..	..	..	..	x
Sapindaceae					
Dodonaea attenuata	x	x	..	x	..
D. bursariifolia	x	..	..	..	..
D. viscosa var. _arborescens_	..	x	..	..	..
Heterodendrum oleifolium	x	..	..	x	..
Scrophulariaceae					
Morgania floribunda	..	..	..	x	..
*_Veronica arvensis_	..	..	x	..	..
Solanaceae					
Lycium australe	..	..	..	x	..
*_L. ferocissimum_	x	..	x	x	x
Nicotiana goodspeedii	x	..	..	..	..
N. velutina	x	..	..	..	..
*_Solanum elaegnifolium_	..	..	..	..	x
S. esuriale	..	x	x	..	x
S. ferocissimum	..	x	..	..	..
*_S. nigrum_	x	x	..	..	..
Thymelaeaceae					
Pimelea microcephala	..	x	..	..	..
P. trichostachya	x	..	..	..	..
Urticaceae					
*_Urtica urens_	x	..	..	..	..
Verbenaceae					
*_Verbena bonariensis_	..	..	..	x	..
*_V. officinalis_	..	..	..	..	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
Zygophyllaceae					
Nitraria billordieri	..	..	..	..	x
Tribulus occidentalis	..	x	..	..	..
Zygophyllum eremaeum	..	x	..	..	..
Z. gloucum	..	..	..	..	x
Z. iodocorpum	..	..	..	x	x
Z. ovotum	..	..	..	x	..
MONOCOTYLEDONS					
Amaryllidaceae					
Calostemma purpureum	x	..	..	..	..
Cyperaceae					
Carex inversa	x	..	x	..	..
Eleocharis ocuta	x	..	x	..	..
E. obicis	..	..	x	..	..
E. palleus	x	..	..	..	x
E. plana	..	..	..	x	..
Fimbristylis dichotoma	x	..	x	..	..
Juncaceae					
Juncus oridicola	..	x	x	..	..
J. bufonius	..	..	x	..	x
J. rodula	x	..	..	..	..
Juncaginaceae					
Triglochin calcitrapa	..	..	..	x	..
Liliaceae					
Anguillario dioica	x	..	x	..	..
Arthropodium minus	x	..	..	..	..
Bulbine alata	x	..	..	..	x
B. bulbosa	x	..	..	..	x
B. semibarbata	..	..	x	x	..
Dianella laevis	x	x	..	..	..
Thysanotus boueri	..	x	x	x	x
T. tuberosus	..	..	..	x	..
Poaceae					
Agropyron scabrum	x	x	x	x	x
Agrostis avenaceo	x	..	x	x	x
**Alopecurus geniculatus*	x	..	..	x	..
Amphibromus neesii	x	..	x	..	..
Aristida behriona	x	x	..	..	..
A. calycino	..	x	..	..	..
A. contorta	..	x	..	..	..
A. echinato	..	x	..	..	..
A. jerichoensis var. *subspinulifera*	..	x	..	..	..
Astrebla pectinata	x	..	..	..	x
**Avena fatua*	x	..	..	..	..
Bothriochloa biloba	..	x	..	..	..
B. macra	..	x	..	..	..
Brachiaria milliiformis	x	..	..	..	..
Bromus arenarius	..	..	..	x	x
Chloris aciculoris	x	x	x	..	..
C. truncata	x	x	x	x	x
Cymbopogon obtectus	..	x	..	..	..
Cynodon doctylon	..	x	..	..	..
Danthonio caespitosa	x	x	x	x	x
Dichanthium sericeum	..	x	..	..	..
Digitaria brownii	..	x	..	..	..
D. coenicola	x	x	..	..	..
D. divaricatissima	..	..	x	..	..
D. hystrichoides	..	x	..	..	..
Diplachne fusca	..	..	x	..	x
D. muelleri	..	..	..	..	x

Botanical name	Booberoi	Cobar	Micabil	Sayers Lake	Trida
Enneapogon avenaceus	..	x	..	x	x
E. intermedius	..	x	..	..	..
E. nigricans	x	..	..	..	..
E. polyphyllus	..	x	..	..	..
Eragrostis australasica	x	..	..	x	x
E. brownii	..	..	x	..	..
**E. cilianensis*	..	x	..	..	..
E. dielsii	..	..	x	x	..
E. eriopoda	..	..	..	x	..
E. parviflora	..	..	x	..	x
E. setifolia	..	..	..	x	x
Eriochloa australiensis	..	..	..	..	x
E. pseudoacrotricha	x	..	x	x	x
**Hordeum leporinum*	x	x	x	x	x
Iseilema vaginiflorum	..	..	..	..	x
**Koeleria phleoides*	..	..	..	x	..
**Lolium perenne*	..	..	x	..	..
**L. rigidum*	x	..	..	..	..
Lophochloa cristata	..	..	..	x	..
L. pumila	..	..	..	x	..
Monochather paradoxa	..	x	..	..	..
Neurachne munroi	..	x	..	..	..
Panicum decompositum	..	x	..	x	..
P. prolutum	..	..	..	x	..
P. queenslandicum var. *queenslandicum*	x	..	..	..	x
P. subxerophilum	..	x	..	..	..
P. whitei	x	..	x	..	x
**Parapholis incurva*	x	..	x	x	..
**P. strigosa*	..	..	..	..	x
Paspalidium constrictum	..	x	..	..	..
Perotis rara	..	..	..	x	..
**Phalaris aquatica*	..	..	x	..	..
**P. paradoxa*	x	..	x	x	..
Poa fordeana	..	..	..	..	x
**Schismus barbatus*	x	x	x	x	x
Sporobolus actinocladus	..	..	..	..	x
S. caroli	x	..	x	x	x
Stipa bigeniculata	..	..	x	..	..
S. elegantissima	x	..	..	..	..
S. falcata	..	..	..	x	..
S. scabra	..	x	x	..	..
S. setacea	..	x	..	..	..
S. tuckeri	..	x	..	..	..
S. variabilis	x	x	..	x	x
Thyridolepis mitchelliana	..	x	..	..	..
Tragus australianus	..	..	x	..	..
Tripogon loliiformis	..	..	x	..	..
Triraphis mollis	..	..	..	x	..
Vulpia myuros	x	..	x	..	x
Xanthorrhoeaceae					
Lomandra effusa	..	x	..	..	..

FLORISTICS OF THE SITES

Number of species recorded

Overall, the study indicated that no fewer than 401 species or varieties of plants from 61 families and 191 genera were recorded over the five sites. The area supporting the most species was Sayers Lake (156 species), followed by Cobar (152), Booberoi and Trida (142) and lastly Micabil (108). These figures should be regarded as an initial assessment of the species assemblage at each site. It should also be borne in mind that the communities at each site are dynamic, responding differently to differing amounts or seasonal incidence of rainfall. Consequently, it is unlikely that all species will be found at a site at the one time.

Naturalized species

Of the 401 species recorded over the five sites, 55, or 13.75%, were exotic species which have become naturalized in the area. These species represent 17 families and 38 genera. The most prominent families were Poaceae (13 species), Asteraceae and Fabaceae (10 species each) and Brassicaceae (6 species). Two species from the family Verbenaceae were recorded, while the remaining twelve families contributed one species each.

The list of naturalized species contains one shrub, *Lycium ferocissimum*, and 54 grasses and forbs. Forty-one of these are annuals, 4 are annual to biennial, while the remaining 9 are perennials.

The proportion of naturalized species varies from 10% at Trida to 20% at Micabil. The overall figure of 13.75% compares very closely with the 13.05% of introduced species recorded by Turner (1903, 1904) for the area of New South Wales west of the 147° meridian of longitude. On the other hand, Leigh and Mulham (1977) found that 29% of the species on the Riverine Plain were naturalized. The network of rivers, creeks, swamps and irrigation channels across the Plain, together with more intense human settlement and land use, creates more favourable conditions for the spread and establishment of naturalized species.

From these species collections it appears that naturalized species are now a part of the vegetation and will persist in the regeneration areas for a very long time, even in the absence of grazing. As they are mainly annuals, it is probable that many of the naturalized species were abundant before exclosure but recent observations show that now they are often not abundant in the areas even after favourable climatic periods. On adjacent areas, which are still grazed by stock, naturalized species are often locally abundant, as is the case of Patersons Curse (*Echium plantagineum*) near Sayers Lake. This appears to be due to the fact that, in the absence of grazing, the total plant cover tends to be dominated by perennial forbs and grasses as was shown by Green, Walker & Cunningham (1976) at Cobar.

Uncommon native species

Several uncommon species have increased their numbers and maintained themselves in the regeneration areas. Such species include *Eleocharis obicis*, which was thought to be very rare or extinct but which is locally abundant at Micabil, and *Astrebla pectinata*, which grows at the Booberoi Regeneration Area over a considerable area (c. 0.5 ha). This species was first described from specimens collected in the locality by Mitchell in 1836, but is now not known to occur in the district other than in the regeneration area.

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VEGETATION OF THE AGNES BANKS SAND DEPOSIT, RICHMOND, NEW SOUTH WALES

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ABSTRACT

Benson, D. H. (*National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia* 2000) 1981. *Vegetation of the Agnes Banks sand deposit, Richmond, New South Wales. Cunninghamia* 1 (1): 35-57. The vegetation of an isolated deposit of Pliocene-Pleistocene sand, at Agnes Banks (lat. 33° 37′ S, long. 150° 41′ E) 55 km northwest of Sydney, New South Wales, which has floristic and structural affinities with both coastal heath vegetation and Hawkesbury Sandstone vegetation, was mapped and described. Low open-forest of *Banksia serrata* and *Angophora bakeri* was confined to the well-drained crests of the large dunes, woodland of *Eucalyptus sclerophylla, A. bakeri* and *B. serrata* was on well-drained and moderately well-drained positions, woodland of *E. sclerophylla, E. parramattensis* and *B. serratifolia* was on shallow sand, low open-woodland of *E. parramattensis* was confined to poorly-drained situations and sedgeland of *Lepidosperma longitudinale* was in depressions where drainage was severely impeded. Classification and ordination analyses indicate that species distribution is dominated primarily by a moisture drainage factor which produces a continuum of species. Projective canopy cover and fire also influence the distribution of the vegetation.

INTRODUCTION

Just southeast of the village of Agnes Banks (lat. 33° 37′ S, long. 150° 41′ E), 5 km southwest of Richmond, New South Wales, large Scribbly Gums (*Eucalyptus sclerophylla*), twisted Angophoras (*Angophora bakeri*), tall Banksias (*Banksia* spp.) and a host of coastal dune species flourish on an expanse of gently undulating white sand. The whole site is in many ways similar to coastal sand dune vegetation, such as that of Myall Lakes (Osborne & Robertson, 1939). Agnes Banks, however, is 55 km from the present coast and on the western margin of the Cumberland Plain, an undulating to flat area of heavy clay soils supporting a grassy woodland quite unlike that on the sand deposit. Average annual rainfall at Richmond is 790 mm (Bureau of Meteorology, 1979), which is similar to that of the Cumberland Plain but much lower than on the coast (average annual rainfall at Sydney is 1 209 mm).

About half the original sand area had been cleared or quarried by 1972 and most of the remainder committed for future sand extraction. Only a small area at the southern end will be preserved. Such an unusual area of vegetation warrants study. The description given here provides information on the structure of the vegetation and species composition, which will be useful for comparative studies, management of the remaining area and possible restoration of adjacent mined areas.

General Description of the Area

The sand at Agnes Banks was first mentioned by Maze (1942) and described in detail by Simonett (1950). The deposit is of white sand and originally covered an area of some 600 ha. The sand forms a series of low, stable, longitudinal dunes aligned east-west, with maximum amplitude of 6 m, though 3 to 4 m is more common. To the south the dunes fade into undulations. Drainage in the centre of the dune area is internal, swamps being formed in swales between the main dunes. The sand has been strongly podsolized, with a hardpan close to the surface in the swales, but discontinuous or absent from the dune crests. Sand extraction has now removed the larger dunes and disturbed much of the original drainage pattern.

Gobert (1978) described the "Agnes Banks Sand" as a stratigraphic unit of Pliocene or Pleistocene age, and probably a fluvial deposit which has been redistributed by westerly winds. Lateritized Tertiary alluvial deposits, mainly clays and silts, surround and underlie the sand, these in turn overlying the extensive Triassic Wianamatta Group which makes up the Cumberland Plain to the south and east. To the west are the Recent alluvial flats of the Hawkesbury-Nepean River, and beyond them the Triassic Hawkesbury Sandstone of the lower Blue Mountains is exposed along the Lapstone Monocline (New South Wales Dept. of Mines, 1966).

The vegetation on the sand deposit is mainly woodland to low woodland with some smaller areas of open-scrub (structural forms follow Specht, 1970). The dominant tree species, *Eucalyptus sclerophylla*, *E. parramattensis* and *Angophora bakeri*, are associated with a species-rich sclerophyllous shrub understorey, common species being *Banksia serrata*, *B. serratifolia*, *Ricinocarpos pinifolius*, *Dillwynia glaberrima*, *Leptospermum attenuatum*, *Conospermum taxifolium*, *Philotheca salsolifolia* and *Acacia brownii*. On the surrounding areas of clay the dominant tree species is *Eucalyptus fibrosa* subsp. *fibrosa*, though *E. sclerophylla*, *E. parramattensis* and *Angophora bakeri* occur occasionally. The rich shrub understorey is replaced by a more open one, predominantly of *Melaleuca decora* and *Bursaria spinosa* with a dense ground cover of grasses.

Phillips (1947) described the vegetation on both the sand deposit and the Tertiary alluvial deposits as belonging to her *Eucalyptus crebra* [*E. racemosa*]-*Angophora bakeri* Association but distinguished the Agnes Banks vegetation in a separate shrub-stratum group characterized by *Banksia serrata*. Forster *et al.* (1977) listed the main tree and shrub species on the sand deposit and included it in a list of areas of botanical conservation interest.

VEGETATION DESCRIPTION

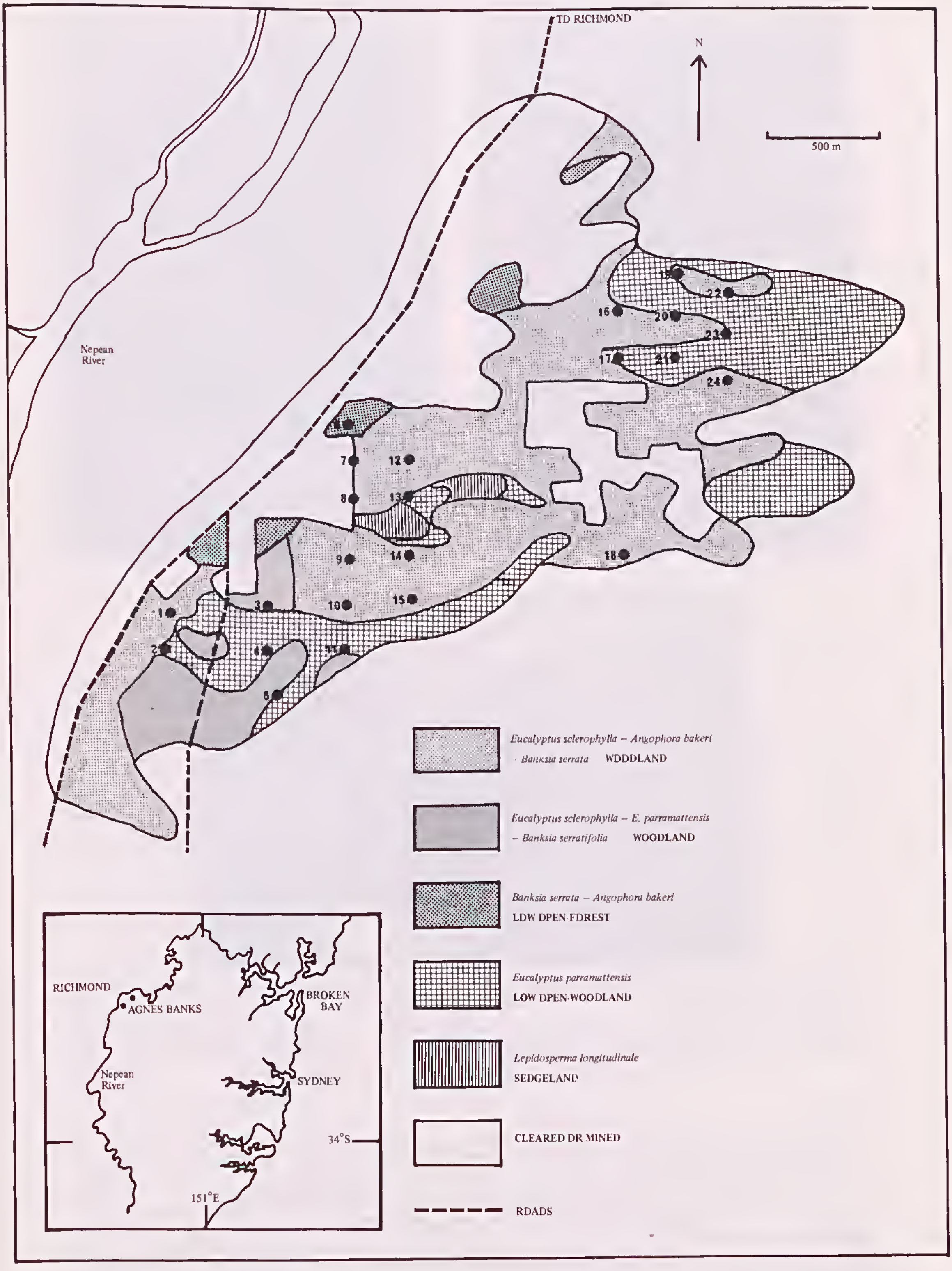
Methods

Black and white aerial photography (Cumberland 1970 series, scale 1:15 000, date 9.7.1970 and Penrith series, scale 1:40 000, date 27.6.1966) and field traverses were used to prepare a vegetation map (Figure 1) showing the vegetation types extant in 1970. Tree canopy cover and topographic position were the main characteristics used to distinguish the different communities on the aerial photography. Field observations confirmed that these were related to species groups, and indicated particularly that drainage was an important factor in plant distribution.

In September 1976 the vegetation was sampled at 250 m intervals along north/south transects, the transects being chosen subjectively in order to sample the five plant communities. As considerable clearing had been carried out since 1970, sample points falling on cleared or mined areas were ignored, leaving 24 in essentially undisturbed native vegetation, though 8 of these had been burnt within the previous two years.

Mining and consequently destruction of the plant communities has been uneven. The highest dunes have generally been mined first, so that only small areas of their vegetation remained whereas there were still large areas of vegetation on shallower sand. Since sand depth appears to influence plant community composition, the sampling of the five communities was uneven and the majority of sampling points were located in the two communities occupying the greatest area of remaining vegetation, the *Eucalyptus sclerophylla-Angophora bakeri-Banksia serrata* woodland and the *Eucalyptus parramattensis* low open-woodland. Two communities had only one sampling point in them and one community was not sampled. Several points had been sampled previously in 1975, similar data being recorded. These data were not used in the later numerical analyses but were included in the basal area and stem density descriptions.

At each sample point all vascular plant species present within a 20 x 20 m square quadrat, hereafter referred to as a sample site, were listed or collected for later identification, and stem diameters of all individuals greater than 5 cm (d.b.h.) were recorded. Projected canopy foliage cover was measured at 50 points within the site, using a vertical sighting tube with cross-wires. Notes were made on important shrub species, position on dune, drainage, aspect, slope and evidence of fire or other disturbance.


TO RICHMOND
N
500 m
Nepean River
1
2
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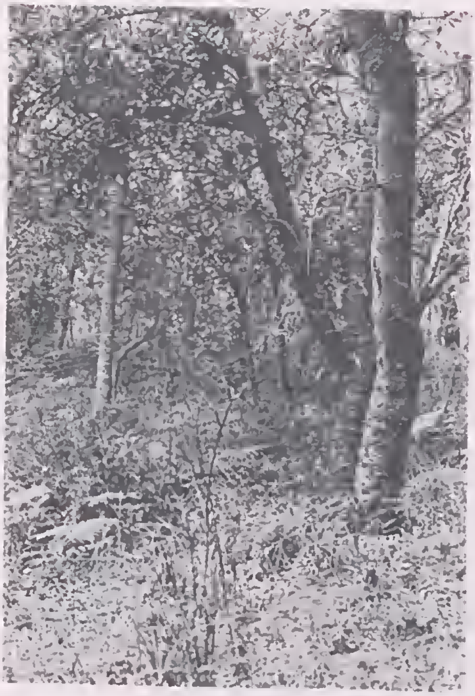
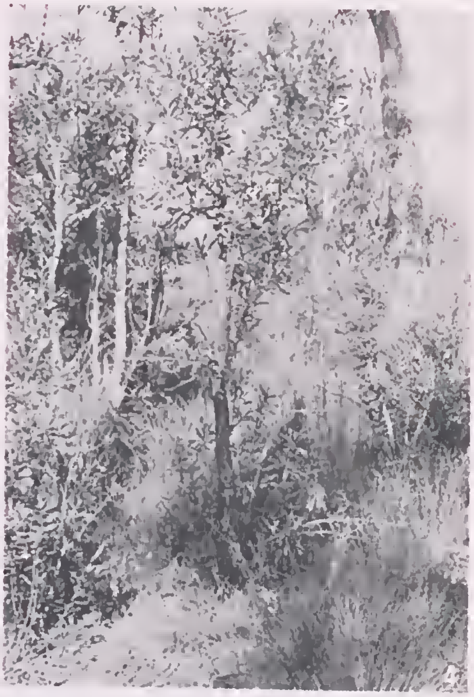
23
24
Eucalyptus sclerophylla – Angophora bakeri · Banksia serrata WOODLAND
Eucalyptus sclerophylla – E. parramattensis – Banksia serratifolia WOODLAND
Banksia serrata – Angophora bakeri LOW OPEN-FOREST
Eucalyptus parramattensis LOW OPEN-WOODLAND
Lepidosperma longitudinale SEDGELAND
CLEARED OR MINED
ROADS
RICHMOND
AGNES BANKS
BROKEN BAY
Nepean River
SYDNEY
34°S
151°E

Figure 1. Vegetation map of Agnes Banks sand deposit in 1970 showing sampling sites.





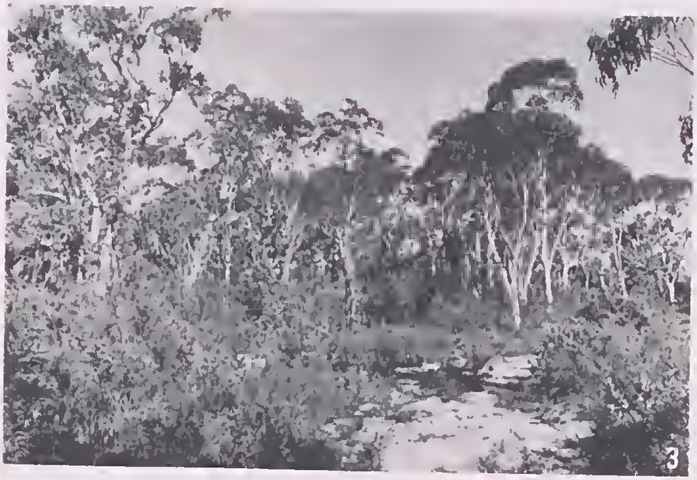


Figure 2. Low open-forest of *Banksia serrata* and *Angophora bakeri*. Understorey mainly *Pteridium esculentum*.

Figure 3. Woodland of *Eucalyptus sclerophylla*, *Angophora bakeri* and *Banksia serrata*.

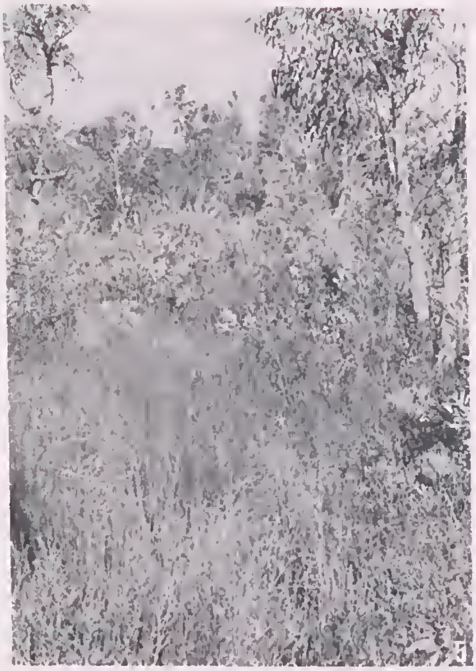
Figure 4. *Banksia serratifolia* in woodland of *Eucalyptus sclerophylla*, *E. parramattensis* and *Banksia serratifolia*. Sedges predominate in foreground.

Results

Five communities were recognized and their distributions are shown in Figure 1.

1. LOW OPEN-FOREST of *Banksia serrata* and *Angophora bakeri*.

A community apparently originally confined to the well-drained crests of the large dunes, most of which have been completely removed by sand extraction. The main trees are *Banksia serrata* and *Angophora bakeri*, up to 10 m high but the community may have occasional large, emergent trees of *Eucalyptus sclerophylla* (Scribbly



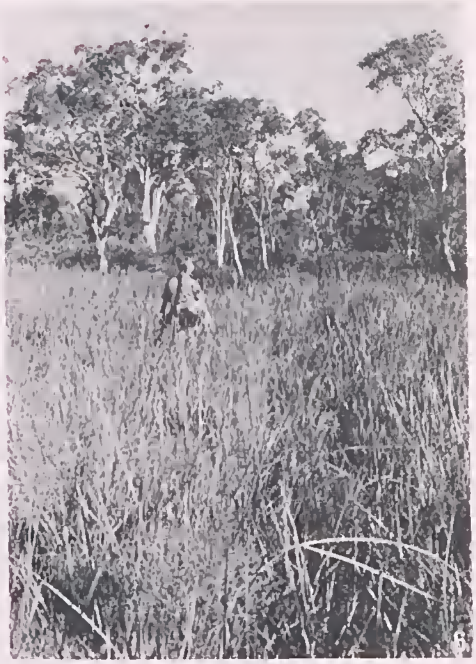


Figure 5. Low open-woodland of *Eucalyptus parramattensis* with *Banksia aspleniifolia*.

Figure 6. Sedgeland of *Lepidosperma longitudinale* and *Melaleuca thymifolia* with woodland of *E. sclerophylla* in background.

Gum) up to 13 m. There is an open understorey of *Pteridium esculentum* and *Imperata cylindrica* and scattered shrubs including *Ricinocarpos pinifolius*, *Eriostemon myoporoides* and *Bossiaea rhombifolia*.

2. WOODLAND of *Eucalyptus sclerophylla*, *Angophora bakeri* and *Banksia serrata*.

This is the most widespread community, found on well-drained and moderately well-drained sites. It is dominated by trees of *Eucalyptus sclerophylla* 10 to 15 m high, together with smaller trees of *Angophora bakeri* and *Banksia serrata*. A large number of sclerophyllous shrub species is characteristic of the understorey, common species being *Leptospermum attenuatum*, *Conospermum taxifolium*, *Ricinocarpos pinifolius* and *Isopogon anemonifolius*.

3. WOODLAND of *Eucalyptus sclerophylla*, *Eucalyptus parramattensis* and *Banksia serratifolia*.

At the southern end of the sand deposit is woodland that is also dominated by *Eucalyptus sclerophylla* but appears to be restricted to shallower or less well-drained sand than Community 1. Small trees of *E. parramattensis* (Drooping Red Gum) up to 10 m high and large shrubs of *Banksia serratifolia* up to 7 m are generally present. An understorey of sclerophyllous shrubs, similar to that in Community 2 is usually present.

4. LOW OPEN-WOODLAND of *Eucalyptus parramattensis*.

This community is confined to poorly-drained situations. Small trees of *E. parramattensis* less than 10 m high, either in clumps or as scattered individuals, are dominant though *E. sclerophylla* and *Angophora bakeri* may be present occasionally. The understorey is dominated by *Banksia aspleniifolia*, which in the most low-lying areas forms a low shrubland, devoid of trees. Large tussocks of sedges and rushes are common. One sedge species, *Restio pallens*, common on the north coast of New South Wales and in southern Queensland, reaches its southern limit at Agnes Banks.

5. SEDGELAND of *Lepidosperma longitudinale*.

Sedgeland, with the small shrub *Melaleuca thymifolia*, occurs in a limited area in depressions between the main dunes where drainage is severely impeded.

The floristic composition of the sand dune area, the frequencies of many species (based on 24 sampling sites) and their growth-forms are shown in Table 1.

TABLE 1

Species recorded on the Agnes Banks sand, with MULTBET species groups, growth-forms, frequencies of occurrence and mode of regeneration after fire.

MULTBET species group	Botanical name	Growth-form	Frequency of occurrence % (24 sites)	Regeneration after fire V = vegetative S = seedling
	PTERIDOPHYTES			
	Adiantaceae			
1	*Cheilanthes tenuifolia*	Fb	8	?V
	Dennstaedtiaceae			
6	*Pteridium esculentum*	Fb	33	V
	Schizaeaceae			
..	*Schizaea bifida*	Fb	4	?V
	GYMNOSPERMS			
	Zamiaceae			
..	*Macrozamia spiralis*	sS	8	V
	ANGIOSPERMS			
	DICOTYLEDONS			
	Apiaceae			
1	*Platysace ericoides*	sS	83	V
1	*Trachymene incisa*	Fb	92	V S
	Apocynaceae			
..	*Parsonsia straminea*	Cl	4	..
	Asteraceae			
..	*Cassinia aculeata*	sS	..	..
..	*C. uncata*	sS	8	..
..	**Conyza albida*	Fb	8	?S
..	*Helichrysum diosmifolium*	sS	4	V
4	**Hypochoeris radicata*	Fb	46	S
..	*Lagenifera stipitata*	..	4	..
..	*Senecio quadridentatus*	Fb	4	..
	Campanulaceae			
..	*Wahlenbergia* sp.	Fb	8	..
	Cassythaceae			
..	*Cassytha glabella*	Tw	4	?S
3	*C. pubescens*	Tw	67	?S
	Casuarinaceae			
..	*Casuarina littoralis*	tS	4	?S
	Dilleniaceae			
..	*Hibbertia diffusa*	sS	4	..
3	*H. fasciculata*	sS	75	S
	Droseraceae			
5	*Drosera peltata*	Fb	13	..
..	*D. pygmaea*	Fb	8	..
5	*D. spathulata*	Fb	17	..
	Epacridaceae			
3	*Brachyloma daphnoides*	sS	54	V
2	*Leucopogon ericoides*	sS	54	S
3	*L. virgatus*	sS	46	V
3	*Monotoca scoparia*	sS	67	V
..	*Styphelia laeta*	sS	4	..
	Euphorbiaceae			
4	*Amperea xiphoclada*	Gr	50	V
..	*Poranthera microphylla*	..	4	?S
3	*Ricinocarpos pinifolius*	S	79	V

MULTBET species group	Botanical name	Growth-form	Frequency of occurrence % (24 sites)	Regeneration after fire V = vegetative S = seedling
	Fabaceae			
7	*Bossiaea heterophylla*	sS	25	V
3	*B. rhombifolia*	sS	63	V
7	*Daviesia acicularis*	sS	13	..
2	*Dillwynia floribunda*	sS	54	S
3	*D. glaberrima*	sS	79	V S
7	*Gompholobium minus*	sS	38	S
6	*Hardenbergia violacea*	Tw	33	V
6	*Hovea linearis*	sS	33	V
..	*Indigofera australis*	sS	4	V
..	*Mirbelia rubiifolia*	sS	4	..
..	*Pultenaea elliptica*	sS	..	..
	Goodeniaceae			
..	*Dampiera stricta*	Fb	..	V
3	*Goodenia bellidifolia*	Fb	25	..
..	*Scaevola ramosissima*	Fb	4	..
	Haloragaceae			
5	*Gonocarpus micranthus*	Fb	33	?V
	Loganiaceae			
6	*Mitrasacme polymorpha*	Fb	33	S
	Mimosaceae			
2	*Acacia brownii*	sS	63	V
..	*A. bynoeana*	sS	4	..
2	*A. elongata*	S	75	V
..	*A. floribunda*	tS	..	?S
..	*A. parramattensis*	tS	..	?S
3	*A. ulicifolia*	sS	54	S
	Myrtaceae			
3	*Angophora bakeri* AAABD	sT	71	V S
..	*A. floribunda* AAABB	T	..	..
2	*Baeckea diosmifolia*	sS	54	V
..	*Callistemon citrinus*	sS	4	V
..	*C. linearis*	sS	8	V
..	*C. pinifolius*	sS	4	V
2	*Eucalyptus parramattensis* SNECF	sT	63	V S
3	*E. sclerophylla* MATKB	sT or T	75	V S
2	*Kunzea capitata*	sS	54	V
3	*Leptospermum attenuatum*	S	75	V
5	*L. flavescens*	S	42	V
..	*L. parvifolium*	sS	4	?V
5	*Melaleuca thymifolia*	sS	13	V
	Olacaceae			
7	*Olax stricta*	sS	21	..
	Polygalaceae			
..	*Comesperma ericinum*	sS	..	S
	Proteaceae			
2	*Banksia aspleniifolia*	S	63	V S
3	*B. serrata*	tS or sT	54	V S
5	*B. serratifolia*	tS	17	V S
7	*B. spinulosa*	S	38	V
3	*Conospermum taxifolium*	sS	67	V S
6	*Grevillea mucronulata*	sS	21	V S
5	*Hakea sericea*	S	13	S
..	*H. dactyloides*	S	4	?V
3	*Isopogon anemonifolius*	sS	63	V S
7	*Persoonia laurina*	sS	30	V
3	*P. nutans*	sS	58	S
5	*Petrophile pulchella*	S	13	S
..	*P. sessilis*	sS	8	..
	Rubiaceae			
..	*Opercularia* sp.	Fb	4	..
7	*Pomax umbellata*	sS	17	..

MULTBET species group	Botanical name	Growth-form	Frequency of occurrence % (24 sites)	Regeneration after fire V = vegetative S = seedling
	Rutaceae			
..	*Eriostemon myoporoides*	S	..	..
6	*Philotheca salsolifolia*	sS	42	V
	Santalaceae			
..	*Omphacomeria acerba*	sS	..	..
	Solanaceae			
..	*Duboisia myoporoides*	S	..	?V
	Stylidiaceae			
1	*Stylidium graminifolium*	Fb	88	V
	Thymelaeaceae			
1	*Pimelea linifolia*	sS	100	S
	MONOCOTYLEDONS			
	Centrolepidaceae			
..	*Centrolepis strigosa*	Gr	8	..
	Cyperaceae			
2	*Cyathochaeta diandra*	Gr	38	V
..	*Lepidosperma longitudinale*	Gr	..	..
..	*Ptilanthelium deustum*	Gr	8	V
1	*Schoenus brevifolius*	Gr	71	V
3	*S. ericetorum*	Gr	54	V
	Haemodoraceae			
1	*Haemodorum corymbosum*	Gr	88	V
	Iridaceae			
..	*Patersonia sericea*	Gr	4	..
	Juncaceae			
7	*Juncus continuus*	Gr	13	V
..	*J. planifolius*	Gr	..	..
	Liliaceae			
..	*Burchardia umbellata*	Gr	..	..
..	*Dianella laevis*	Gr	8	?V
4	*D. revoluta*	Gr	46	?V
..	*Stypandra caespitosa*	Gr	..	..
	Orchidaceae			
..	*Caladenia alba*	Gr	4	?V
..	*Caleana major*	Gr	..	?V
7	*Calochilus* sp.	Gr	17	?V
..	*Glossodia minor*	Gr	4	?V
..	*Microtis* sp.	Gr	4	?V
..	*Pterostylis longifolia*	Gr	4	?V
..	*Thelymitra aristata*	Gr	..	?V
..	*T. longifolia*	Gr	8	?V
	Poaceae			
..	*Aristida ramosa*	Gr	4	..
..	*A. vagans*	Gr	17	..
..	*A. warburgii*	Gr	4	..
..	*Cynodon dactylon*	Gr	4	..
6	*Digitaria parviflora*	Gr	33	..
4	*Entolasia stricta*	Gr	67	..
4	*Eragrostis brownii*	Gr	46	..
..	*E. leptostachya*	Gr	4	..
..	*Imperata cylindrica*	Gr	8	V
..	*Microlaena stipoides*	Gr	4	?V
..	**Setaria geniculata*	Gr	4	..
..	*Themeda australis*	Gr	4	..
	Restionaceae			
7	*Hypolaena fastigiata*	Gr	21	V
5	*Leptocarpus tenax*	Gr	25	?V
..	*Lepyrodia muelleri*	Gr	..	?V
2	*L. scariosa*	Gr	63	?V
5	*Restio pallens*	Gr	21	V

MULTBET species group	Botanical name	Growth-form	Frequency of occurrence % (24 sites)	Regeneration after fire V = vegetative S = seedling
	Xanthorrhoeaceae			
7	*Lomandra cylindrica*	Gr	33	V
7	*L. filiformis*	Gr	8	V
4	*L. glauca*	Gr	67	V
7	*L. longifolia*	Gr	25	V
..	*L. multiflora*	Gr	4	V
..	*Xanthorrhoea minor*	Gr	67	V
..	*X. resinosa* subsp. *resinosa*	Gr		
	Xyridaceae			
..	*Xyris complanata*	Gr	4	..

* = exotic species

Nomenclature follows Jacobs & Pickard (in press). *Eucalyptus* and *Angophora* codings follow Pryor & Johnson (1971). *Acacia brownii* is correctly so spelled, not "brownei".

Growth-form: T = tree, sT = small tree, tS = tall shrub, S = shrub, sS = small shrub, Fb = forb, Gr = graminoid, Cl = climber, Tw = twiner.

Regeneration after fire: ? indicates likely mode based on growth-form or on Purdie & Slatyer (1976).

Table 2 shows structural data for the plant communities arranged in order of increasingly impeded drainage. In general structural characters measured appear to be correlated with this gradient. Basal area, stem density, canopy cover and bare ground per cent are all highest in the well drained low open-forest and woodland communities and decrease towards the sedgeland while ground cover density shows the reverse trend. Only canopy height does not follow this trend, being highest in the woodland communities. The low open-forest may originally have had emergent trees. A few stumps exist but from the small remnants surviving it is now difficult to be certain how common these emergent trees may have been.

Tables 3 and 4 show basal area and densities for the tree species in these communities. Again a gradient in dominance can be observed from well drained to poorly drained, species ordering being *B. serrata-A. bakeri-E. sclerophylla-B. serratifolia-E. parramattensis.*

The distributions of species within a number of genera are interesting. Carolin (1970) pointed out that at Myall Lakes, species in the same genus frequently showed distinctly different habitat preferences apparently related to soil drainage, though possibly due to competition. At Agnes Banks there is evidently a similar situation with regard to the following species, *Dillwynia glaberrima* and *D. floribunda*, *Leptospermum attenuatum* and *L. flavescens*, and *Banksia serrata*, *B. serratifolia* and *B. aspleniifolia.*

Fire also appears to be an important ecological factor. Fire has been common in the past. There are charcoal remains on many trees, even at sites where a dense shrub understorey and leaf litter suggest that it is some years since the last burning. Adaptations to fire are very common in the vegetation, and many species regenerate from underground perennating organs such as lignotubers or rhizomes. The mode of regeneration of 65 species was recorded (Table 1). Of these, over 80% of species showed evidence of vegetative resprouting and less than 20% regenerated by seedlings alone. Among these were a number of genera within which species responded differently. *Dillwynia floribunda*, *Acacia ulicifolia* and *Leucopogon ericoides* regenerate only by seedlings but *Dillwynia glaberrima*, *Acacia brownii*, *A. elongata*, and *Leucopogon virgatus* may survive fire and resprout. Species relying solely on seedling establishment do not appear to show any preference for either more or less frequently burnt sites and are distributed through most plant communities.

TABLE 2

Structural data for 20 x 20 m quadrats in mapped plant communities

	Low open-forest *B. serrata* *A. bakeri*	Woodland *E. sclerophylla* *A. bakeri* *B. serrata*	Woodland *E. sclerophylla* *E. parramattensis* *B. serratifolia*	Low open-woodland *E. parramattensis*	Sedgeland
Number of 20 x 20 m sites recorded*	1 (1)	14	1	8	(1)
Estimated canopy height (m)	(9)–10	8–20	12	6–12	(1)
Canopy cover (%)	52–(67)	6–44	6	2–16	not measured
Basal area (m²/ha)	33.0, (43.5)†	15.4 SD 9.3	9.1†	6.5 SD 4.7	(0)†
Stem density (stem/ha)	950, (1 675)†	671 SD 280	525†	375 SD 217	(0)†
Ground cover density	mid-dense to open	dense to open	mid-dense	dense to mid-dense	dense
Estimated % bare ground	(40)–50	10–60	30	5–30	(0)

* Sites in brackets were the 20 x 20 m sites recorded in April 1975. They are not included in the later numerical analyses.

† = actual figures.

TABLE 3

Mean basal areas (m^2/ha) for tree species in mapped plant communities

Species	Low open-forest *B. serrata* *A. bakeri*	Woodland *A. bakeri* *B. serrata*		Woodland *E. sclerophylla* *E. parramattensis* *B. serratifolia*		Low open-woodland *E. parramattensis*	
	Mean basal area m^2/ha	Mean basal area m^2/ha	Percentage of total basal area	Mean basal area m^2/ha	Percentage of total basal area	Mean basal area m^2/ha	Percentage of total basal area
Banksia serrata	20.8, (23.3)†	2.2 SD 2.3	14	..	..	0.1 SD 0.2	1
Angophora bakeri	22.7, (9.7)†	7.9 SD 6.3	51	1.3†	14	0.2 SD 0.5	3
Eucalyptus sclerophylla	..	4.4 SD 4.8	28	0.9†	10	1.7 SD 3.8	26
Banksia serratifolia	..	0.2 SD 0.8	1	6.9†	76	0.01 SD 0.03	<1
Eucalyptus parramattensis	..	0.5 SD 1.2	3	..	..	4.5 SD 2.3	69
Number of 20 x 20 m sites recorded*	1 (1)	14	..	1	..	8	..

* = sites in brackets were 20 x 20 m sites recorded in April 1975. They are not included in the later analyses.

† = actual figures.

TABLE 4

Mean plant densities (plants/ha) for tree species (>5 cm dbh) in mapped plant communities

Species	Low open-forest *B. serrata* *A. bakeri*	Woodland *A. bakeri* *B. serrata*		Woodland *E. sclerophylla* *E. parramattensis* *B. serratifolia*		Low open-woodland *E. parramattensis*	
	Mean plant density pls/ha	Mean plant density pls/ha	Percentage of total density	Mean plant density pls/ha	Percentage of total density	Mean plant density pls/ha	Percentage of total density
Banksia serrata	800, (1·000)†	125 SD 126	23	..	..	28 SD 80	10
Angophora bakeri	125, (675)†	259 SD 140	47	125†	28	6 SD 18	2
Eucalyptus sclerophylla	..	41 SD 29	7	125†	28	34 SD 44	12
Banksia serratifolia	..	18 SD 67	3	200†	44	3 SD 9	1
Eucalyptus parramattensis	..	25 SD 47	5	..	..	212 SD 142	75
Number of 20 x 20 m sites recorded*	1 (1)	14	..	1	..	8	..

* = Sites in brackets were 20 x 20 m sites recorded in April 1975. They are not included in the later analyses.

† = Actual figures.

VEGETATION ANALYSIS

Methods

During mapping and description of the plant communities, considerable intergradation between them was recognized. This was particularly noticeable in the understorey species, whose topographic positions appeared to reflect a gradient of drainage change, both across the five communities, and within particular communities. There was also evidence of frequent fire, (charcoal remains on trees, dead shrub remains, localized patches of species regarded as indicators of frequent fire, e.g. *Pimelea linifolia*) and the question of its importance in determining the distribution of shrub species was raised.

The data from the 24 sampling sites recorded in 1976 were therefore subjected to both classification and ordination analyses. Because of the concentration of most sampling in two communities, the *E. sclerophylla-Angophora bakeri-Banksia serrata* woodland and the *E. parramattensis* low open-woodland, most discussion is confined to the relationships within and between these two. However, some idea of the relationships of the two communities each represented by only one site may be indicated by the position of those sites in the classification or ordination analyses.

Presence/absence data of species recorded from more than 10% of the sites, i.e. more than 2 of the 24, (Table 1) were analysed using programs from the TAXON library on the CSIRO CSIRONET Control Data Cyber 76 computer. Programs used were the agglomerative polythetic classification program MULTBET (Lance & Williams, 1967), the principal coordinate ordination program GOWER (Gower, 1966) and the diagnostic programs GROUPER and GOWECOR. Of 131 species recorded from the sites, 70 were used in the analyses. Both normal and inverse MULTBET analyses were carried out and the results plotted in a two-way table of site groups against species groups.

Results

Following convention the MULTBET analyses are discussed as though divisive, i.e. down the hierarchy. In the normal analysis the first major division is between well-drained and poorly-drained sites, the former corresponding generally to sites in the *Eucalyptus sclerophylla-Angophora bakeri-Banksia serrata* woodland and the latter to sites in the *Eucalyptus parramattensis* low open-woodland. Species contributing to the dry-site groups are *Leptospermum attenuatum*, *Bossiaea rhombifolia*, *Ricinocarpos pinifolius* and *Isopogon anemonifolius*. These are generally known to be species of well-drained or deep sandy situations. Species contributing to the wet-site groups are *Leptospermum flavescens*, *Drosera spathulata*, *Baeckea diosmifolia* and *Gonocarpus micranthus*, species normally found in poorly-drained or moist situations.

Lower divisions in the analysis could not be interpreted satisfactorily.

The first axis of the GOWER ordination of sites (accounting for 26.8% of the variation) is interpreted as reflecting a moisture/drainage gradient (Figure 7). Species correlated with ordination axes were obtained from the diagnostic program GOWECOR. Positively correlated with the first axis were *Acacia ulicifolia* (0.83), *Leptospermum attenuatum* (0.83), *Bossiaea rhombifolia* (0.81), *Ricinocarpos pinifolius* (0.76) and *Hovea linearis* (0.75), species of well-drained or deep sandy situations. Negatively correlated were *Leptospermum flavescens* (−0.85), *Baeckea diosmifolia* (−0.81), *Gonocarpus micranthus* (−0.76), *Leptocarpus tenax* (−0.75) and *Drosera spathulata* (−0.74), species normally found in poorly-drained or moist situations.

The response of the species to the postulated moisture/drainage gradient is shown in Table 5. Here the MULTBET species groups, arranged approximately according to the first GOWECOR species axis, are tabulated against the sites arranged in first GOWER site axis order. Though some species are restricted to either the well-drained or poorly-drained ends of the gradient, many species overlap.

TABLE 5

Ordination of sites by first GOWER axis (moisture/drainage gradient) tabulated against MULTBET species groups arranged approximately according to first GOWER species axis.

Well-drained sites————————————————→ Poorly-drained sites

Species groups	Botanical name	7	8	12	6	14	9	16	22	3	13	15	19	10	18	24	1	17	23	2	4	20	5	21	11
3	*Acacia ulicifolia*	x	x	x	x	x	x	x	x	x	x	..	x	..	..	x	x	..	..	..	..	..	..	..	x
	Angophora bakeri	x	x	x	x	x	x	x	x	x	x	x	x	x	..	x	x	..	x	..	..	..	..	..	x
	Bossiaea rhombifolia	x	x	x	x	x	x	x	x	x	x	..	x	x	..	x	..	x	x	..	..	..	..	..	..
	Leucopogon virgatus	x	..	x	..	x	..	x	..	x	x	x	x	x	..	..	..	x	x	..	..	..	..	..	..
	Schoenus ericetorum	x	x	x	..	x	x	x	x	x	x	x	x	..	..	x	..	..	..	x	..	..	..	..	..
	Banksia serrata	x	x	x	x	x	x	x	..	x	x	x	..	..	x	x	..	x	..	..	..	..	..	..	..
	Brachyloma daphnoides	..	x	x	x	x	x	x	x	x	..	x	..	x	x	x	..	..	..	x	..	..	..	..	..
	Cassytha pubescens	x	x	x	x	x	x	x	..	..	x	x	..	x	x	x	x	x	..	x	..	..	x	..	..
	Conospermum taxifolium	..	x	x	..	..	x	x	x	..	x	x	x	x	x	x	..	x	..	x	x	x	..	..	x
	Dillwynia glaberrima	x	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	x	x	..	x	..	..
	Eucalyptus sclerophylla	x	x	x	..	x	x	x	x	x	x	x	..	x	x	x	x	..	x	..	..	x	x	..	x
	Hibbertia fasciculata	x	x	x	..	x	x	x	x	..	x	x	x	x	x	x	x	x	x	x	..	x	..	..	..
	Isopogon anemonifolius	x	x	x	x	x	x	x	..	x	x	x	..	x	x	x	..	..	x	..	..	..	..	..	x
	Leptospermum attenuatum	x	x·	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	..	..	..	..	..
	Monotoca scoparia	x	x	x	x	x	x	x	x	x	x	x	..	x	x	x	..	..	..	x	..	..	x	..	..
	Persoonia nutans	x	x	x	x	x	x	x	..	..	x	x	..	..	x	..	x	x	x	x	..	..	..	..	..
	Ricinocarpos pinifolius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	..	..	..	..
1	*Haemodorum corymbosum*	x	x	x	x	x	..	x	x	x	x	x	x	x	x	x	..	x	x	x	x	x	x	x	..
	Pimelea linifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Platysace ericoides	x	..	..	x	x	..	x	x	x·	x	x	x	x	x	..	x	x	x	x	x	x	x	x	x
	Schoenus brevifolius	..	..	..	..	x	..	x	x	x	..	x	x	..	x	x	x	x	x	x	x	x	x	x	x
	Stylidium graminifolium	x	x	x	x	x	x	x	x	x	..	x	x	x	..	x	x	x	x	x	..	x	x	x	x
	Trachymene incisa	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	x	x	x	x	x	x	x	..	x
4	*Amperea xiphoclada*	x	x	..	..	..	..	x	x	x	x	..	..	..	..	x	x	x	..	x	x	..	x	..	..
	Dianella revoluta	x	x	..	x	x	x	x	x	..	..	x	x	..	..	..	x	..	..	..	..	x	..	..	..
	Entolasia stricta	x	x	x	x	..	..	x	..	x	x	..	x	..	x	..	x	x	x	x	x	x	..	x	..
	Eragrostis brownii	x	..	..	x	..	x	..	x	..	..	x	x	..	..	..	x	x	..	x	x	..	..	x	..
	Hypochoeris radicata	x	x	..	x	..	x	..	..	x	x	x	x	x	x	..	x	x	..	..	..	..	..	..	..
	Lomandra glauca	x	x	..	x	x	x	..	x	x	x	x	x	x	x	x	x	x	..	..	x	..	..	..	..

Species Group	Botanical name	7	8	12	6	14	9	16	22	3	13	15	19	10	18	24	1	17	23	2	4	20	5	21	11
6	*Digitaria parviflora*	x	x	..	..	..	x	x	x	x	x	..	..	..	..	..	x	..	..	..	..	..	..	..	..
	Grevillea mucronulata	x	x	x	x	..	..	..	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hardenbergia violacea	x	x	x	x	x	..	x	..	..	x	..	x	..	..	..	..	..	..	..	..	..	..	..	..
	Hovea linearis	x	x	x	x	x	..	x	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Mitrasacme polymorpha	x	x	..	..	..	x	x	..	x	x	x	..	x	..	..	..	..	..	..	..	..	..	..	..
	Philotheca salsolifolia	x	x	x	x	..	x	..	x	x	..	x	..	..	..	..	..	..	x	..	..	..	..	..	..
	Pteridium esculentum	x	x	x	x	x	..	x	..	..	x	..	..	..	..	..	x	..	..	..	..	..	..	..	..
2	*Acacia brownei*	..	..	..	..	x	x	..	x	x	..	..	x	x	x	x	..	x	x	x	..	x	x	x	x
	Acacia elongata	..	x	..	..	x	x	..	..	x	x	x	x	x	x	x	x	..	x	x	x	x	x	x	x
	Cyathochaeta diandra	..	x	..	..	..	..	..	x	x	x	x	x	x	..	..	..	..	..	..	x	..	..	x	..
	Dillwynia floribunda	..	x	..	..	..	x	..	x	x	..	x	x	..	..	..	..	..	x	x	x	x	x	x	x
	Kunzea capitata	..	..	..	..	..	..	..	..	x	x	x	x	x	x	..	..	x	x	..	x	x	x	x	x
	Leucopogon ericoides	..	x	..	..	x	x	..	..	..	..	x	x	..	x	..	x	x	x	x	..	x	..	x	x
	Baeckea diosmifolia	..	..	..	..	..	..	..	..	..	x	x	..	x	x	..	x	x	x	x	x	x	x	x	x
	Banksia aspleniifolia	..	x	..	..	..	..	x	..	x	x	x	..	x	x	x	x	x	x	x	x	x	x	x	..
	Eucalyptus parramattensis	..	..	..	..	..	..	x	..	x	x	..	x	..	x	x	x	x	x	x	x	x	x	x	x
	Lepyrodia scariosa	..	..	..	..	..	..	x	..	..	x	x	..	x	x	x	x	x	x	x	x	x	x	x	x
7	*Banksia spinulosa*	..	x	..	..	x	..	x	..	x	..	..	..	..	..	..	..	x	..	..	..	x	x	x	x
	Lamandra cylindrica	..	x	..	x	..	..	..	..	..	x	..	..	x	..	..	x	..	..	x	..	..	x	x	..
	Lomandra longifolia	..	..	..	x	..	..	..	..	..	x	..	x	..	..	..	x	x	..	..	..	..	..	..	x
	Persoonia laurina	..	..	..	x	x	..	x	..	x	..	..	..	..	..	..	x	..	x	..	..	..	x	..	..
	Pomax umbellata	..	..	..	x	..	..	..	..	..	..	..	x	x	..	..	x	..	..	..	..	..	..	..	..
	Bossiaea heterophylla	..	..	..	..	..	x	..	x	..	..	..	x	x	..	x	..	x	..	..	..	..	..	..	..
	Calochilus sp.	..	..	..	..	x	x	..	..	..	x	..	..	..	..	..	..	..	x	..	..	..	..	..	..
	Daviesia acicularis	..	x	..	..	..	..	..	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Gompholobium minus	..	x	..	..	x	x	..	x	..	x	x	x	..	..	..	..	x	..	..	..	..	x	..	..
	Hypolaena fastigiata	..	..	..	..	..	..	x	..	..	..	x	..	..	x	x	..	..	x	..	..	..	..	..	..
	Juncus continuus	..	..	..	..	..	..	..	..	..	x	..	..	..	..	x	..	..	..	..	..	..	x	..	..
	Lomandra filiformis	..	x	..	..	..	..	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Olax stricta	..	x	..	..	..	..	..	..	..	x	x	..	..	x	..	..	..	x	..	..	..	..	..	..
5	*Banksia serratifolia*	..	..	..	..	..	..	..	..	x	..	..	..	x	..	..	..	..	..	x	x	..	..	..	..
	Drosera peltata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	x	x
	Drosera spathulata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	x	..	x	x	..
	Gonocarpus micranthus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	..	x	x	x	x	x	x	x
	Goodenia bellidifolia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	x	x	..	..	x	x	x
	Hakea sericea	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	..	x	..	..	x
	Leptocarpus tenax	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	x	x	x	x	..	x
	Leptospermum flavescens	..	..	..	..	..	..	..	..	..	..	..	x	x	..	..	x	x	x	x	x	x	x	..	x
	Melaleuca thymifolia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	x	..	x
	Petrophile pulchella	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..	x	..	..	x	..	..	..	..	..
	Restio pallens	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	x	..	x	x	..	x	..	..

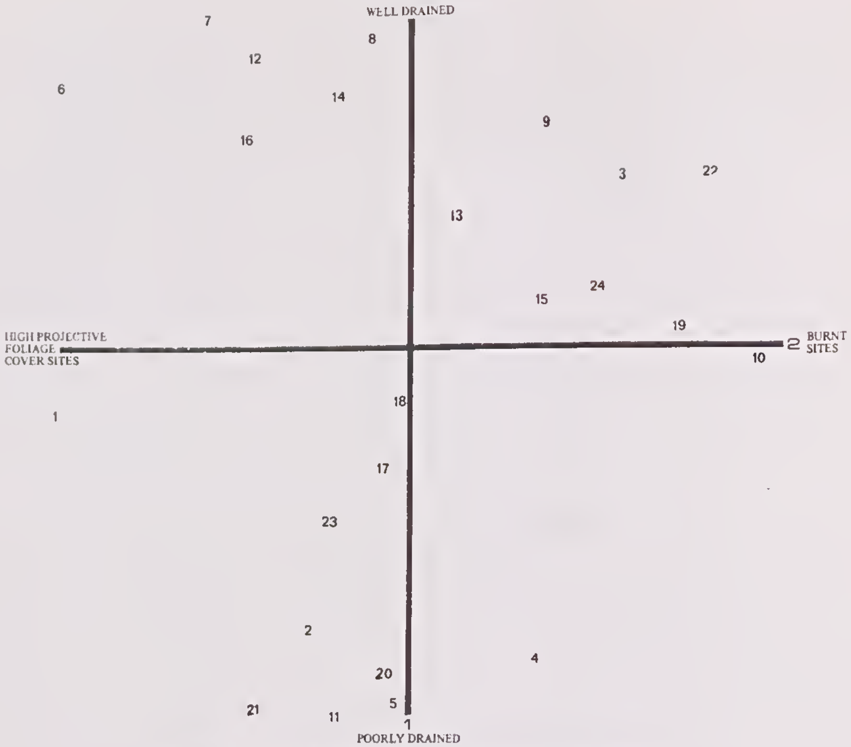


Figure 7. The first two axes of the site ordination.

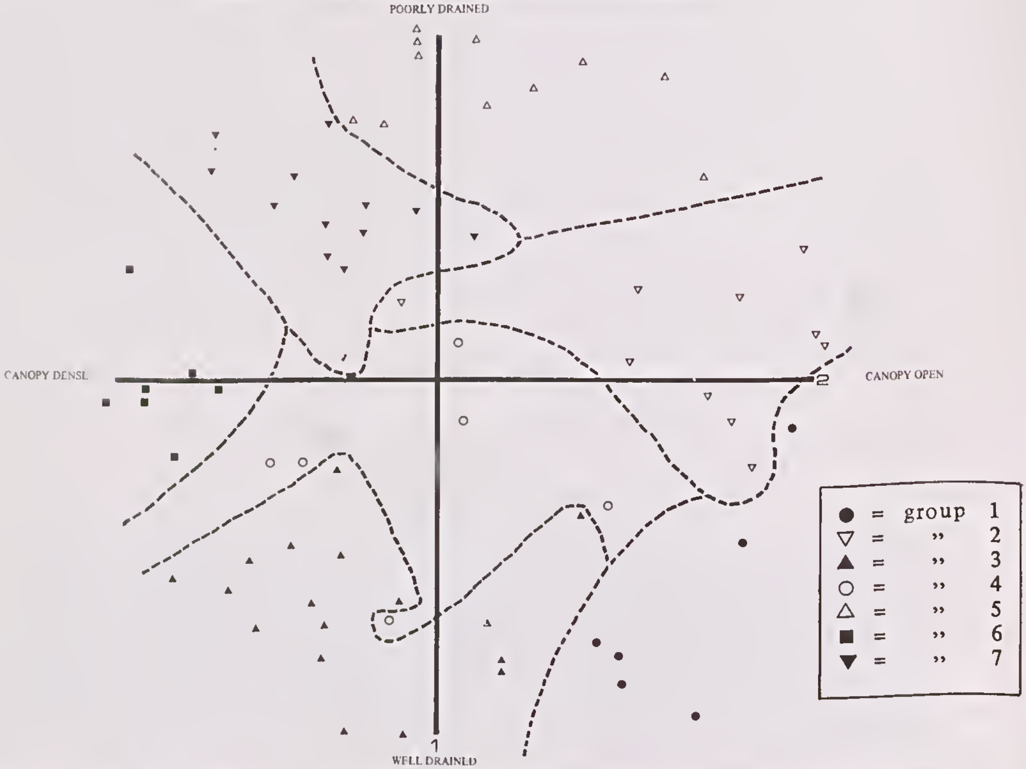


Figure 8. The first two axes (moisture/drainage and canopy cover) of the species ordination showing the separation of the species groups (see Tables 5 and 6 for composition of groups).

By inspection, however, a division can be drawn, probably between sites 1 and 17, a division which almost entirely agrees with the first division of the MULTBET site classification. The habitats indicated by the MULTBET species groups are given in Table 6.

The second site axis (accounting for 8.2% of variation) has burnt sites at one end, and sites with highest projective foliage cover at the other. Species positively correlated are *Bossiaea heterophylla* (0.70), *Acacia brownei* (0.50) and *Cyathochaeta diandra* (0.59). The first two species resprout vegetatively after fire although they are legumes, which generally regenerate rapidly from seed. *Cyathochaeta diandra* is reported by Siddiqi *et al.* (1976) as the most abundant species in the earliest stages of regrowth after fire in coastal ground-water heath in Bouddi National Park. Negatively correlated are *Pteridium esculentum* (−0.61), *Entolasia stricta* (−0.58) and *Persoonia nutans* (−0.55). *Pteridium esculentum*, a rhizomatous fern, is common after fire but removed by regular burning. *Entolasia stricta* may appear rapidly after burning but persists for a long time afterwards. From field observations, only *Persoonia nutans* seems to be restricted to sites with a dense projective foliage canopy cover that are not frequently burnt.

The third axis (accounting for 8.1% of variation) again has burnt sites at one end, but is not related to projective foliage cover. Species positively correlated are *Hypochoeris radicata* (0.50), an exotic species which may indicate disturbance, *Dillwynia floribunda* (0.47) which regenerates from seed after fire and *Eragrostis brownii* (0.46). Species negatively correlated are *Hypolaena fastigiata* (−0.67), *Lepyrodia scariosa* (−0.58) and *Olax stricta* (−0.58). Siddiqi *et al.* (1976) included *Hypolaena fastigiata* in a list of low-growing species which grew well in the early stages of regrowth after a fire and recorded *Lepyrodia scariosa* within a year of burning.

The first two axes of the species ordination account for 26.1 and 19.3% of the variance in the vegetation data respectively. The first axis is again related to a moisture/drainage gradient (Figure 8) and confirms the importance of the character in determining the type of vegetation. The second axis appears to be related to the site projective foliage cover. Sites positively correlated with this axis are sites 20 (4% projective foliage cover), 21 (4%), 5 (8%), 11 (4%) and 2 (16%). Site 6, with the highest projective foliage cover of all sites (52%), is negatively correlated with this axis. Members of species-group 6 are concentrated at the high canopy cover end of the axis (Figure 8). This group includes *Pteridium esculentum*, which had a correlation with high canopy cover along site axis 2, and *Hardenbergia violacea* and *Grevillea mucronulata*. The latter two species generally colonize disturbed sites, particularly where the canopy has been destroyed, yet here appear to be confined to sites where disturbance has been minimal and projective foliage cover is high. Axis 3 (6.1% of variation) is possibly related to fire; there is a positive correlation with burnt sites 19 (0.61) and 22 (0.57). Species at the positive end of the axis are *Eragrostis brownii*, *Entolasia stricta*, *Amperea xiphoclada*, *Bossiaea heterophylla* and *Olax stricta*.

Quantitative Analysis

The separation of the sites into two communities is illustrated by Figure 9, which shows percentage basal areas for the dominant tree species. *Angophora bakeri* and *Eucalyptus parramattensis*, the two main dominants, are very rarely found together, and are confined to the dry and wet communities respectively. *Banksia serrata* is most common at the very dry end, but *Eucalyptus sclerophylla* does not appear to be influenced by variations in moisture/drainage and occurs in many situations.

Figure 10 shows the projective foliage cover change along the gradient. The dry sites, although showing marked fluctuations have a high projective foliage cover (mean [transformed data] = 24% + 15.8, −12.8) and confirm the use of the structural formation woodland (Specht, 1970) while the wet sites (mean [transformed data] = 6% + 5.1, −3.6) are in open-woodland.

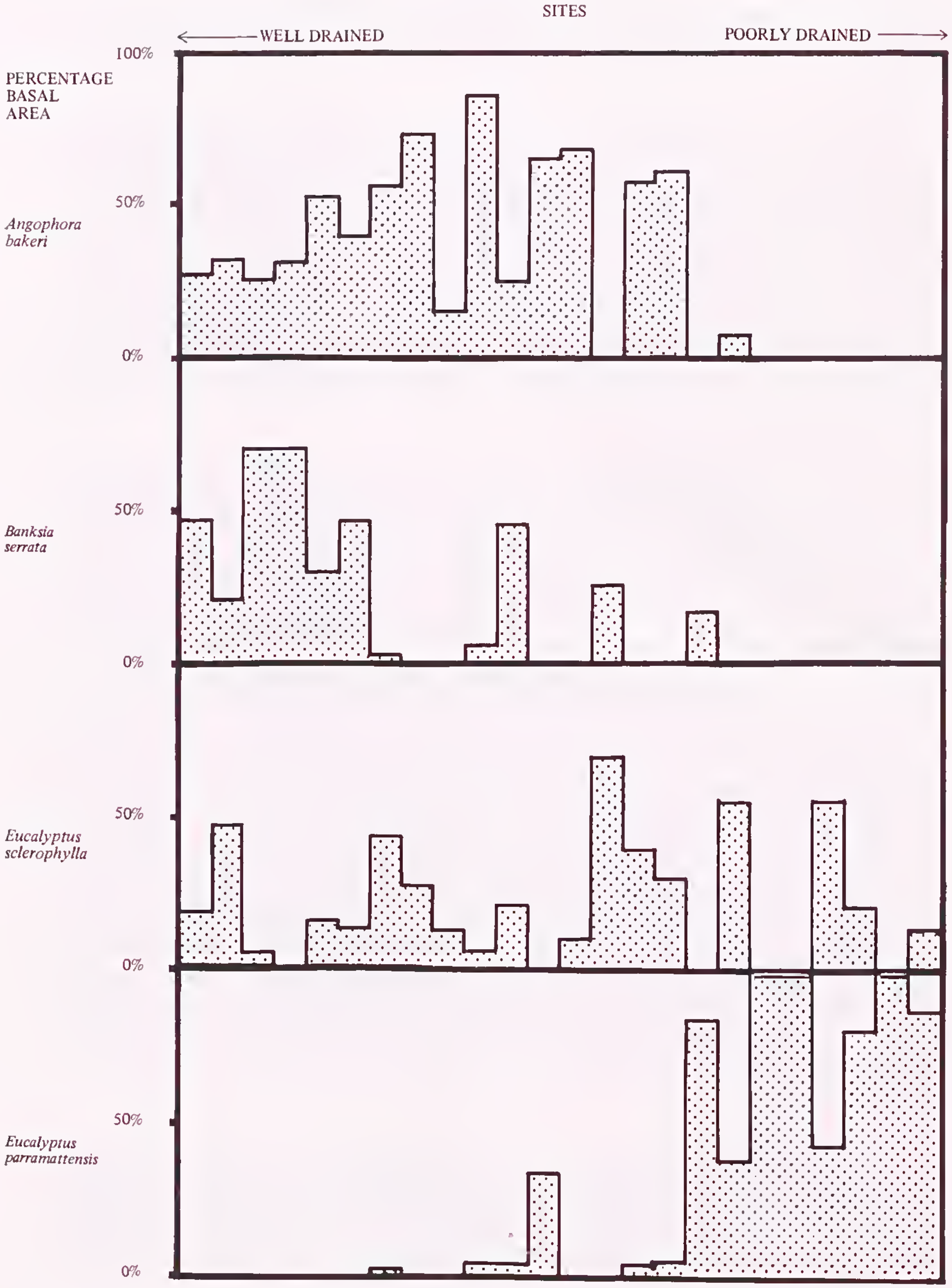


Figure 9. Percentage basal area for *Angophora bakeri*, *Banksia serrata*, *Eucalyptus sclerophylla* and *E. parramattensis*.

TABLE 6

Habitats and life-forms indicated by Multbet Species Groups

Species Group 1

Species occurring on almost all sites, indicating presence of sandy soil but evidently not reflecting drainage, moisture, fire or disturbance conditions.

2 shrubs, 2 herbs, 2 graminoids.

Species Group 2

Species occurring on most sites except those of site group 10 which are dry sites with high canopy cover recordings.

7 shrubs, 1 small tree.

Species Group 3

Species occurring regularly on all dry sites and on occasional wet sites. Species completely absent from wet sites are *Acacia ulicifolia*, *Bossiaea rhombifolia*, *Leucopogon virgatus*, *Schoenus ericetorum*, *Banksia serrata*, *Brachyloma daphnoides*, *Leptospermum attenuatum*, *Persoonia nutans* and *Ricinocarpos pinifolius*.

2 trees, 13 shrubs, 1 graminoid, 1 twiner.

Species Group 4

Species occurring irregularly on all sites. All graminoids except *Hypochoeris radicata*, a rosette herb and the only exotic weed included in the analysis.

Species Group 5

Species restricted to wettest or most poorly drained sites.

5 shrubs, 4 herbs, 2 graminoids.

Species Group 6

Species restricted to driest sites but also appear to be correlated with high projective canopy cover readings. Sites may be burnt, though most have not been for a long time.

3 shrubs, 1 graminoid, 1 herb, 1 twiner and 1 fern.

Species Group 7

Species of low frequency occurring sporadically on any sites. No concentrations with any site groups evident.

7 shrubs, 1 herb, 5 graminoids.

DISCUSSION

An estimate of the similarity of the vegetation at Agnes Banks to that of other areas is difficult to make in the absence of comparative sampling. On a visual impression it appears to be most similar to coastal vegetation, but this impression is probably influenced by the presence of the white, dune sand topography, which is unlike that of typical Hawkesbury Sandstone country of much of the Sydney district. Structurally the vegetation is sclerophyllous woodland, similar to both Hawkesbury Sandstone vegetation and coastal vegetation. Floristically, there are also similarities with both types. Of the tree species, *Eucalyptus sclerophylla*, *Angophora bakeri* and *Banksia serrata* all occur on Hawkesbury Sandstone. *E. parramattensis* is found on sandy soils, though not commonly on Hawkesbury Sandstone. Only *B. serratifolia* is restricted to coastal sand-dune areas, the nearest recorded locality to Agnes Banks being Cooper Park, near Bondi, a coastal locality, 60 km to the south-east. It is common in the Myall Lakes area where it grows on the sand deposits of apparently lower nutrient status and greater age than those supporting *Banksia serrata* (R. Carolin pers. comm.).

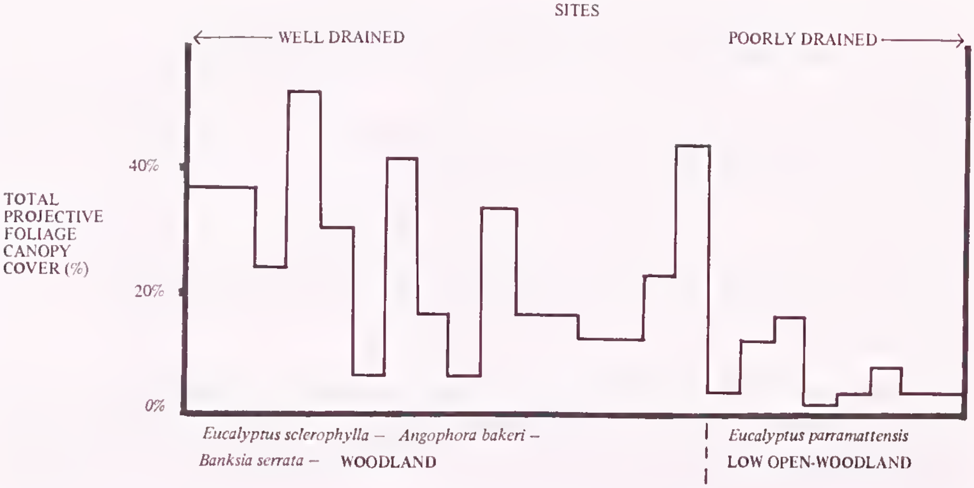


Figure 10. Total projective foliage canopy cover plotted for sites ordinated by first GOWER axis (moisture/drainage gradient). See Table 5 for site order.

The percentage of the Agnes Banks flora recorded from Hawkesbury Sandstone areas and coastal sand dune areas is given in Table 7. Strong affinities with the Sandstone flora are indicated by the similarity with Dharug National Park where 67% of the Agnes Banks flora also occurs. However, considering the large total number of species at Dharug, and the size of the area investigated (c. 12 000 ha), what is probably most surprising is that 33% of species at Agnes Banks were not recorded at Dharug. This is probably due to drainage and nutrient differences between the sandy soils developed on Hawkesbury Sandstone and the deep sands at Agnes Banks, and supports the general view that geology is the major determinant of plant distribution in the Sydney area (Pidgeon, 1937).

Coastal sand dune vegetation affinities are indicated in the 47% of the Agnes Banks flora found at Myall Lakes and the 25% found at North Stradbroke Island, Queensland. Apart from coastal areas, the only similar sand deposit recorded for the Sydney district is on the Mellong Range near Putty, 60 km north of Agnes Banks. Forster *et al.* (1977) describe the vegetation there as Medium Open-forest of *Eucalyptus sclerophylla* and *E. parramattensis.* Although a full species list is not available, a combined list of 64 species included only 31% of the Agnes Banks flora. A full species list is likely to include a higher proportion than this. *Banksia serratifolia* has not been recorded.

The drainage factor has long been used to explain the distributions of plant communities within coastal sand areas. Osborne & Robertson (1939) recognized dune *Eucalyptus* forest, dry heath, wet heath and swamp communities related to sand depth and drainage, each with floristic differences, but also with extensive ecotones between them. Numerical studies by Siddiqi *et al.* (1973) and Connor & Clifford (1971) showed that similar vegetation could be divided into floristic groups related to moisture/drainage conditions. Connor & Clifford found, however, that there was considerable species overlap in the groups formed.

The numerical analyses of the vegetation at Agnes Banks support the descriptions of the two major communities sampled, the *Eucalyptus sclerophylla-Angophora bakeri-Banksia serrata* woodland on dry well-drained sites, and the *Eucalyptus parramattensis* low open-woodland on poorly-drained sites, but emphasize the continuous gradient between them. Of the communities mapped, but only sampled with one site, the site ordination (Table 5) placed the only site in the *Banksia*

TABLE 7

Similarity of Agnes Banks flora to that of coastal dune and Hawkesbury Sandstone floras

Locality	Distance and direction from Agnes Banks	Vegetation	Total species recorded	Number of species in common with Agnes Banks	Percentage of Agnes Banks flora (total 129 spp.)	Reference
Dharug National Park ..	40 km, NE ..	mainly dry sclerophyll forest on Hawkesbury Sandstone	514	86	67%	Matthew (1973)
Myall Lakes	200 km NE on coast	heath forest, dry heath, wet heath on dune sand	204	61	47%	Carolin & Myerscough (1977)
North Stradbroke Island, Queensland	700 km NE off coast	open-forest to herbfield on dune sand	119	32	25%	Connor & Clifford (1972)
Mellong Range	60 km, N ..	medium open-forest on sand	64	40	31%	Forster *et al.* (1977) and author

serrata-Angophora bakeri low open-forest (Site 6) at the well drained end, as expected. Site 3, the only site in the *Eucalyptus sclerophylla-E.parramattensis-Banksia serratifolia* woodland, had been recently burnt and was grouped with intermediate dry sites of the *E. sclerophylla-A. bakeri-B. serrata* woodland most of which had been similarly burnt. In the species classification *Banksia serratifolia* is grouped with species of poorly drained situations (species group 5) whereas *Banksia serrata* is grouped with those of the best drained situations (species group 3). There is no evidence that the sites in the *Eucalyptus sclerophylla-E. parramattensis-Banksia serratifolia* woodland behave differently from sites in the *Eucalyptus sclerophylla-Angophora bakeri-Banksia serrata* woodland though *Banksia serrata* evidently prefers better drained sites than *Banksia serratifolia*. There were no sites in the *Lepidosperma longitudinale* sedgeland, but its floristic composition and topographic position indicate that it would be located at the extreme wet end of the moisture/drainage gradient.

Other factors, particularly fire, and location on supposedly older areas, were also considered important. The analyses indicate that the moisture/drainage factor is by far the dominating influence on plant species distribution, though the quantitative sampling was not detailed enough to show how important it was in determining the abundance of individual species.

The results suggest that projective canopy cover is also an important factor in the distribution of the understorey species. However, the behaviour of two species, should be noted; on nearby areas of different geological substrate (Wianamatta Shale and Hawkesbury Sandstone) *Hardenbergia violacea* and *Grevillea mucronulata* are colonizers following disturbance, which is often associated with canopy removal. On the Agnes Banks sand they are restricted to sites that have the highest cover and have remained unburnt for a long period.

An estimate of the relative importance for plant distribution of the two factors, moisture/drainage and canopy cover, is indicated by the percentage variation these account for in the species ordination. The axis attributed to moisture/drainage accounts for 26.1% of the total variance and that attributed to canopy cover 19.3%. The next three axes together account for only 16.9% of the total variance.

A third factor, fire, though of much less importance, is indicated from general observations and in some of the analyses. Although eight of the 24 sites had been burnt within the previous 2 years (probably in Dec. 1974), no particular site or species groups are clearly indicative of recent fire, though it is indicated in some axis components. Purdie & Slatyer (1976) have reported that, for dry sclerophyll forest near Canberra, most of the regrowth from surviving organs, from residual seed and from seed released after fire, commences in the first 12 months after burning. This seems to be the case for the vegetation at Agnes Banks, and the recording of species presence alone is inadequate to detect differences between areas burnt at different times in the past.

ACKNOWLEDGMENTS

I wish to thank Helen Bryant for her help in collecting the data and preparing the diagrams, and my colleagues at the National Herbarium of New South Wales, particularly R. G. Coveny, S. W. L. Jacobs, M. D. Fox and J. M. Powell for help with the identification of specimens and comments on the manuscript.

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RECENT FLORISTIC LISTS OF NEW SOUTH WALES

H. J. Bryant and D. H. Benson

(Accepted for publication 1.5.1980)

ABSTRACT

Bryant, H. J. and D. H. Benson (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia 2000), 1981. *Recent floristic lists of New South Wales. Cunninghamia* 1 (1): 59–77. One hundred and forty-three floristic lists have been collated with notes on the arrangement of species, ecological information and localities. Twenty-six journals and non-periodicals for the period 1971 to 1979, together with a number of unpublished lists held at the Royal Botanic Gardens, Sydney, provided much of the material. The papers are numbered and related to the botanical subdivisions of New South Wales.

INTRODUCTION

Floristic lists provide a basis for ecological reconnaissance surveys and are frequently the only available source of botanical data for a particular area. Pickard (1972)* compiled a bibliography of floristic lists published to that date. Since then, there has been a considerable increase in the number of workers involved in ecological surveys, particularly for environmental impact studies, and an additional bibliography is needed.

This bibliography covers work published since 1971, together with a large number of unpublished lists which are held at the Royal Botanic Gardens. It also contains a small number of lists published before 1971 which were not included in the bibliography of Pickard (1972). The distribution of studies is uneven and similar to that in Pickard (1972). It reflects past and present land use in New South Wales, with most studies being conducted on the Central and North Coast subdivisions and the least on the South Western Slopes and South Coast.

TYPES OF LISTS INCLUDED

Similar criteria to those of Pickard have been adopted. Recent literature was searched for papers containing any floristic lists for areas within New South Wales. These vary considerably in quality, ranging from regional floras to short lists of predominant species, and may or may not include ecological notes on the vegetation or environment.

Many of the items cited are unpublished. These are housed at the Royal Botanic Gardens and are available on request. Unpublished floristic lists kept by government departments, universities, and other scientific institutions have not been included unless a copy is lodged at the Royal Botanic Gardens. So that they may become more widely available, it is hoped that other unpublished items will be forwarded to the Royal Botanic Gardens to be included in future bibliographies.

ANNOTATIONS

Annotations include the approximate number of species and the botanical arrangement. Where the locality is not clearly indicated by the title, the general area is given. The relevant botanical subdivisions of New South Wales are indicated to the left of the reference. Any ecological notes on habitat, soil type, plant communities, etc. are noted.

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* Pickard, J. (1972). Annotated bibliography of floristic lists of New South Wales. *Contr. New South Wales Natl. Herb.* 4, 291–317.

JOURNALS SEARCHED

The Australian Science Index (CSIRO Central Information, Library and Editorial Section), provided a number of papers from journals not included in those scanned. The following journals were searched, together with a number of non-periodicals for the period 1971 to 1979:

Australian Forestry Research
Australian Journal of Biological Science
Australian Journal of Botany
Australian Journal of Ecology
Australian Journal of Marine and Freshwater Research
Australian Natural History
Australian Plants
Commonwealth Forestry and Timber Bureau Bulletin
Contributions from the New South Wales National Herbarium
CSIRO Australia Division of Plant Industry Technical Papers
CSIRO Australia Soils and Land Use Series
CSIRO Australia Wildlife Research
CSIRO Australia Environmental Research, ECOS
Ecological Monographs
Ecology
Forestry Commission of New South Wales Research Notes
Hunter Natural History
Journal and Proceedings of the Royal Society of New South Wales
Journal of Applied Ecology
Journal of Ecology
Journal of Soil Conservation Service of New South Wales
Proceedings of the Linnean Society of New South Wales
Sunraysia Naturalists Research Trust Report
Telopea
The Orchadian
Victorian Naturalist

INDEX TO BIBLIOGRAPHY

The papers are arranged alphabetically according to authors, numbered and coded for the botanical subdivisions of New South Wales. Papers relevant to each subdivision are listed below by number.

Lord Howe Island (LHI)	115.
North Coast (NC)	1, 3, 6, 7, 8a, 8b, 20, 47, 48, 50, 60, 63, 64, 90, 91, 92, 93, 95, 108, 113, 125, 128, 131, 132, 139, 144, 145, 147, 148.
Central Coast (CC)	4, 5, 9, 11, 12, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 27, 29, 30, 31, 32, 36, 37, 38, 40, 41, 43, 44, 45, 50, 54, 57, 58, 62, 72, 77, 78, 79, 83, 88, 89, 94, 97, 99, 104, 105, 106, 107, 109, 112, 116, 118, 121, 122, 123, 129, 130, 135, 136, 140, 141, 142, 143.
South Coast (SC)	2, 50, 61, 74, 137.
Northern Tablelands (NT)	7, 8a, 8b, 42, 50, 59, 66, 133.
Central Tablelands (CT)	9, 13, 26, 28, 29, 34, 39, 46, 50, 73, 88.
Southern Tablelands (ST)	49, 50, 55, 75, 80, 96, 110, 111, 127, 138, 149.
North Western Slopes (NWS)	7, 8a, 8b, 65, 71, 81, 98.

Central Western Slopes (CWS) ..	7, 8a, 8b, 33, 35, 50, 82, 95, 134.
South Western Slopes (SWS) ..	86, 87.
North Western Plains (NWP) ..	7, 8a, 8b, 51, 53, 101, 117, 126.
South Western Plains (SWP) ..	51, 53, 84, 117.
North Far Western Plains (NFWP)	10, 52, 53, 100, 102, 103, 117.
South Far Western Plains (SFWP)..	51, 53, 56, 67, 69, 70, 85, 102, 117, 120.
New South Wales general (NSW) ..	68, 76, 114, 119, 124, 146.

FLORISTIC LISTS OF NEW SOUTH WALES (1971–1979)

1. Adam, P. & Murray, A. S. (1979). Booti Island—List of species present. (Unpub.).

NC About 70 species are listed in major plant groups within families. Wallis Lake, south of Forster.

2. Adams, L. G. & Craven, L. A. (1976). *Checklist of vascular plants in a study area of the south coast of New South Wales.* CSIRO Austral. Div. of Land Use Res. Technical Memorandum 76/16.

SC Checklist divided into districts for Clyde, Deua-Moruya and Tuross catchment areas covering c. 45% of the South Coast subdivision. About 800 species are listed alphabetically by genera.

3. Anon. (n.d.). Trees, shrubs and climbers collected at various times in the Acacia Creek-Tooloom-Killarney district, northern New South Wales. (Unpub.).

NC About 180 species are listed under families, some authorities given. West of Lismore.

4. Armstrong, J., Benson, D. H. & Coveny, R. (1976). The vegetation of La Perouse. (Unpub.).

CC Brief survey describing 7 plant communities associated with geological units, with comments on species of interest. About 450 species are listed, alphabetically by genera and also by families. Vegetation map. Sydney region.

5. Australian Littoral Society (1977). *An investigation of management options for Towra Point, Botany Bay.* Australian National Parks and Wildlife Service, Canberra.

CC About 320 species of vascular plants are listed under major plant groups within families, with common names and introduced and uncommon species indicated. About 100 lichen species are listed for 3 areas—Towra Point, Hawkesbury River, Port Hacking. Vegetation map. Sydney region.

6. Baxter, N. (1972–78). Wildflowers of the Redhead area. *Hunter Natural History.* Vols 2–8.

NC Descriptions and illustrations of c. 120 species with notes on habitat and locality. In instalments. Vegetation sketch maps. Newcastle area.

7. Beadle, N. C. W. (1972). *Students flora of north eastern New South Wales. Part I. Pteridophytes.* University of New England, Armidale.

NC, NT, NWS, CWS, NWP Description and key to all Pteridophyte taxa. Notes on habitat, common names.

8a. Beadle, N. C. W. (1972). *Students flora of north eastern New South Wales. Part II. Gymnosperms. Key to Angiosperm Families. Angiosperms: Families* 37–83. University of New England, Armidale.

NC, NT, NWS, CWS, NWP Key to all families. Description and key to all taxa in families 37–83. Notes on habitat, common names. Numbering system for families based on Hutchinson, J. (1959) *The families of flowering plants.* Clarendon Press, Oxford.

8b. Beadle, N. C. W. (1976). *Students flora of north eastern New South Wales. Part III. Angiosperms: Families* 84–106. University of New England, Armidale.

NC, NT, NWS, CWS, NWP Description and keys to all taxa in families 84–106. Notes on habitat, common names. Numbering system for families based on Hutchinson, J. (1959) *The families of flowering plants.* Clarendon Press, Oxford.

9. Beadle, N. C. W., Evans, O. D. & Carolin, R. C. (1972). *Flora of the Sydney region.* Reed, Sydney.

CC, CT Revised and enlarged edition of *Handbook of the vascular plants of the Sydney District and Blue Mountains* (1963) by the same authors. Key to all taxa. Descriptions, notes on habitat, common names.

10. Beasley, D. (1979). Checklist of flora identified at Mootwingee Historic site. (Unpub.).

NFWP About 200 species are listed in major plant groups within families, common names given. North-east of Broken Hill.

11. Beecroft Cheltenham Civic Trust (1976). *A plan of management for Pennant Hills Park and some surrounding bushland.* Beecroft Cheltenham Civic Trust.

CC About 150 species are listed, alphabetically by genera under families. Sydney region.

12. Benson, D. H. (1973). Vegetation of Lion Island, Broken Bay. (Unpub.). Since published in *Cunninghamia* **1**, 121–123 (1981).

CC Brief description of vegetation. About 70 species are listed alphabetically by genera. Sydney region.

13. Benson, D. H. (1974). Reconnaissance survey of heath, Kings Tableland, Wentworth Falls. (Unpub.).

CT Brief description of heath vegetation. About 60 species from 2 sites are listed, alphabetically by genera. Blue Mountains.

14. Benson, D. H. (1974). Lists of native species still surviving in parks in some Sydney suburbs. (Unpub.).

CC Number following locality indicates number of native species.
Canterbury Municipal Golf Course, 11
Jubilee Park, Bardwell Park, 14
O'Neill Park, Yagoona, 7
Padstow Park, 21
Potts Hill, Yagoona, 17
Recreation Reserve, Bankstown, 10
Wiley Park, 10.

15. Benson, D. H. (1974). Survey of the natural vegetation of the Hawkesbury River and its tributaries. In H. A. Scholer, *Geomorphology of New South Wales coastal rivers*, pp. 68–89. University of New South Wales Water Research Laboratory Report No. 139.

CC Vegetation structure and distribution associated with geological variation. About 80 species are listed under families for 13 plant communities. Vegetation map. Sydney region.

16. Benson, D. H. (1974). Reconnaissance vegetation survey of Duffys Forest-Terrey Hills area. (Unpub.).

CC Notes on 3 vegetation units. About 76 species are listed for 2 sites, alphabetically under family in major plant groups. Sketch vegetation map. Sydney region.

17. Benson, D. H. (1975). Brief vegetation survey, Campbelltown to Bargo. (Unpub.).

CC Brief description of vegetation units for Menangle, Douglas Park and Pheasants Nest to Bargo. About 75 species are listed, alphabetically by genera, for 3 sites. South of Sydney.

18. Benson, D. H. (1975). Brief survey of native vegetation at Rawson Park, Mosman. (Unpub.).

CC Brief description of plant community, importance and viability. About 75 species are listed, alphabetically by family with exotics indicated. Locality map. Sydney.

19. Benson, D. H. (1975). Native vegetation on lateritic soils—Waterfall area. (Unpub.).

CC Brief survey of native vegetation on lateritic Wahroonga and Woronora Soil Series. Description of eucalypt associations. About 75 species are listed, alphabetically by genera. Sydney region.

20. Benson, D. H. (1976). Vegetation survey of proposed Angourie Tourist Resort. (Unpub.).

NC Seven plant communities and two disturbed units are described with comments on susceptibility to disturbance. About 300 species are listed for 9 units, alphabetically by genera. Vegetation map. North of Grafton.

21. Benson, D. H. (1976). Vegetation survey—Ourimbah Creek. (Unpub.).

CC Brief description of remaining native vegetation. About 50 species are listed, alphabetically by genera. Locality map. West of Gosford.

22. Benson, D. H. (1976). Vegetation survey—Culoul Range. (Unpub.).

CC Brief description of vegetation units divided on geological units, discussion of importance on regional basis. About 75 species are listed alphabetically by genera, for 3 sites. North west of Sydney.

23. Benson, D. H. (1977). Vegetation survey of Bents Basin and associated areas. Wallacia, New South Wales. (Unpub.).

CC Brief description of vegetation. Discussion of importance based on rare species and geomorphology. About 55 species are listed, alphabetically by genera. Locality map. West of Sydney.

24. Benson, D. H. (1977). Native vegetation of Elderslie land management study area, Camden, New South Wales. (Unpub.).

CC Description of remnant native vegetation divided into 3 units based on geology. About 70 species are listed for 3 communities. South west of Sydney.

25. Benson, D. H. (1978). Brief survey of vegetation at Long Bay rifle range. (Unpub.).

CC A brief description of vegetation on Hawkesbury Sandstone. About 90 species are listed for 4 sites, alphabetically by genera, family names given. Vegetation map. Sydney region.

26. Benson, D. H. (1978). Survey of native vegetation at Nattai Gorge and Berrima. (Unpub.).

CT Brief description of vegetation indicating geological influence. About 120 species are listed for 7 sites, alphabetically by genera, family names given. Locality and vegetation map.

27. Benson, D. H. (1978). Brief vegetation survey—Wolli Creek, Undercliffe to Bexley North. (Unpub.).

CC Brief description of remnant native vegetation of inner southern suburb of Sydney. About 120 species are listed, alphabetically by genera under growth-form headings. Sydney region.

28. Benson, D. H. (1978). Native vegetation of the Newnes Plateau. (Unpub.).

CT Description of 9 vegetation units for 7 communities. About 140 species are listed from 11 sites in 6 communities, alphabetically by genera, family names given. Vegetation map. North of Lithgow.

29. Benson, D. H. (1979). Native vegetation from Cockatoo Hill to Wolgan River. (Unpub.).

CC and CT Description of 7 vegetation units. About 120 species are listed covering 4 sites for 3 vegetation units, alphabetically by genera, family names given, exotics indicated. Vegetation map. Northeast of Lithgow.

30. Benson, D. H. (1979). Native vegetation of corridor—Wolgan River to Putty Road. (Unpub.).

CC Description of 4 vegetation communities. About 270 species are listed covering 17 sites for 4 vegetation units, alphabetically by genera, divided into growth forms, family names given, exotics indicated. Vegetation map. Northeast of Lithgow.

31. Benson, D. H. (1979). Plants recorded at Fern Hill, Mulgoa, New South Wales. (Unpub.).

CC About 110 species are listed under growth-forms within families. West of Sydney.

32. Benson, D. H. (1979). Native vegetation of Deep Creek, Narrabeen. (Unpub.).

CC Four vegetation units are described briefly. About 120 species listed under growth-forms. Vegetation map. Sydney region.

33. Benson, D. H. (1979). Native vegetation of sand deposit at "Wolaroi", Mendooran. (Unpub.).

CWS Vegetation community is described. About 60 species are listed under major plant groups within families, related to drainage and compared with other sand-deposit species lists.

34. Benson, D. H. (1979). Brief vegetation survey of Mt Werong and Banshea State Forests and adjacent areas. (Unpub.).

CT Brief description of 8 vegetation units. About 120 species are listed for 8 sites, alphabetically by genus, family names given. South of Oberon.

35. Benson, D. H. (1979). Vegetation of Wongarbon Nature Reserve. (Unpub.).

CWS Short description of vegetation and comments on disturbance. Eighty seven species are listed under major plant groups within families. Near Dubbo.

36. Benson, D. H. (in prep.). Native vegetation of the Cumberland Plain.

CC Detailed description of 18 plant communities on Wianamatta Shale, Tertiary Alluvium and Recent Alluvium, listing about 450 species divided into communities. Vegetation map. Sydney region.

37. Benson, D. H. (1981). Vegetation of upper Mangrove Creek, Wyong, New South Wales. *Cunninghamia* **1**, 7–22.

CC Four plant communities are described and related to aspect and geology. About 200 species are listed, alphabetically by genera. Vegetation map. North of Sydney.

38. Benson, D. H. (1981). Vegetation of the Agnes Banks sand deposit, Richmond, New South Wales. *Cunninghamia* **1**, 35–57.

CC Five plant communities are described and related to drainage and fire factors. About 130 species are listed, alphabetically by genera. Vegetation map. West of Sydney.

39. Benson, D. H. (in prep.). Native vegetation on Mt Jellore, Mittagong, New South Wales.

CT Description of geology, topography. Discussion of aspect effect on vegetation composition and structure. About 85 species are listed for 5 sites, alphabetically by genera, family and growth-form given.

40. Benson, J. S., & Fallding, H. (1979). Vegetation survey of Brisbane Water National Park and environs. (Unpub.).

CC Eighteen plant communities are described and mapped. Six hundred and fifty-five species are listed, alphabetically by genera under major plant groups. Vegetation map. North of Sydney.

Revised version published in *Cunninghamia* **1**, 79–113 (1981).

41. Blaxell, D. F. & Pickard, J. (1969). Floristic list—Lane Cove River. (Unpub.).

CC Brief description of geology, soils and vegetation for 1.6 ha area. About 60 species are listed, alphabetically by family. Sydney region.

42. Bowden, D. C. & Turner, J. C. (1976). *A preliminary survey of stands of temperate rain forest on Gloucester Tops.* Research Papers in Geography, University of Newcastle, New South Wales. No. 10.

NT Tree species associations, densities/habitat for cool temperate rain forest community. Sixteen tree species are listed. North of Newcastle.

43. Bradley, E. & Bradley, J. (1966–1974). Local native plant species, Rawson Park, Mosman, New South Wales. Results of periodic plant surveys, 1966–1974. (Unpub.).

CC About 100 species are listed under major plant groups within families. Sydney region.

44. Buchanan, R. (1977). The Ludovic Blackwood Memorial Sanctuary—description and management. (Unpub.).

CC The plant community is described, with detailed discussion of weed invasion for 9 areas. Recommendations for management are given. About 150 species are listed under major plant groups, in families, Sydney region.

45. Buchanan, R. (1979). Bushland at Burley Griffin Lodge, Avalon. (Unpub.).

CC Description of vegetation around Lodge, comments on abundance of exotic species. About 110 species are listed under structural headings, alphabetically by genera, exotics indicated. Sydney region.

46. Burrough, P. A., Brown, L. & Morris, E. C. (1977). Variations in vegetation and soil pattern across the Hawkesbury Sandstone plateau from Barren Grounds to Fitzroy Falls, New South Wales. *Austral. J. Ecol.* **2**, 137–59.

CT Soil morphology, vegetation formation and species composition dependence on mean annual rainfall. About 110 species are listed, alphabetically by genera under families. South of Robertson.

47. Carolin, R. C. & Martin, A. R. H. (1967?). Provisional floristic list of Myall Lakes area. (Unpub.).

NC About 270 species are listed under families in major plant groups, with plant communities indicated. North of Newcastle.

48. Clark, S. S. (1975). The effect of sand mining on coastal heath vegetation in New South Wales. *Proc. Ecol. Soc. Austral.* 9, 1–16.

NC Measurement of change of species composition before and after sand mining for 2 areas. About 85 species are listed for Bonny Hills area alphabetically by genera under growth form headings. South of Wauchope.

49. Costin, A. B., Gray, M., Totterdell, C. J. & Wimbush, D. J. (1979). *Kosciusko alpine flora.* CSIRO—Collins, Sydney.

ST Detailed sections on communities, and keys and descriptions to species. About 200 species are listed under major plant groups within families with growth-forms, habitat and common names plus a naturalized species list.

50. Coveny, R. (1960s–1979). Ninety-two checklists of plant sightings and collections. (Unpub.).

Lists of species, alphabetically by genera with exotics indicated by asterisk, for the following localities—listed below alphabetically followed by date(s) then number of species.

NC Bundjilung Nature Reserve, Evans Head (1972–77), c. 160
Carrai State Forest, west of Kempsey (1968), c. 150
The Broadwater National Park (1977), c. 130

CC Additions to Green Scrub list (Hungerford et al. 1976–78), Bilpin, via Mountain Lagoon (1978), c. 50
Bass Point Reserve, south of Shellharbour (1977), 58
Bents Basin, Wallacia (1970–75), 101
Brisbane Water National Park, near Gosford (1969–78), c. 360 for 2 sites
Brush Farm, Eastwood, Sydney (1978), c. 100
Casula, 2FC radio station site, near Liverpool (1965–78), 218
Cheltenham, Sydney (1965–78), c. 400
Cowan to Jerusalem Bay, Kuring-gai Chase, Sydney (1965–70), c. 320
Culoul Range-Colo River Gorge (1976–77), 432
Cumberland State Forest, Baulkham Hills, Sydney (1976), c. 220
Darvall Park, Denistone, Sydney (1978), 106; additions and corrections (1979), c. 50
Deep Creek, Narrabeen, Sydney (1965–75), 409
Deewhy Lagoon, Sydney (1970–72), 277
Dharug National Park (1972–77), c. 270
East Hills area, Picnic Point and Deadmans Creek, Sydney (1960–70), 238 for 4 sites.
Elouera Bushlands Reserve, Sydney (1970), c. 350 in major plant groups, family and common names given
Frenchs Forest, Sydney (1965–70), 406
Georges River Park, Sydney (1966), c. 100
Glebe Gully, Randwick, Sydney (1977), 39
Glen Davis area (1976–77), c. 210
Gospers Creek, a tributary of the Colo River (1977–78), c. 70
Hallstrom Nature Reserve, Muogamarra, North of Sydney (1962–69), c. 210 for 2 sites
Heathcote National Park:
    Abaroo Track (1979), c. 200 for 2 sites inside and outside Park,
    Additions to Bullawaring Track (1978), c. 50,
    Mooray Track (1968–78), c. 260,
    Sarahs Knob (1977–78), c. 270.
Helensburgh, Sydney (1967–72), c. 150
Katandra Sanctuary, Mona Vale, Sydney (1975–79), c. 400
Kelly Falls, near Helensburgh (1979), c. 220
Kurnell Peninsula Historical Site, Sydney (1960–77), c. 350
Lake Parramatta Reserve, Sydney (1960–65), c. 230

La Perouse, Sydney (1970–78), c. 400
Linden, Blue Mountains (1960–70), c. 240
Longneck Lagoon, Cattai (1974), 108
Mt Kuring-gai to Apple Tree Bay, Sydney (1960–65), c. 180
Manly Reservoir, Sydney (1965–70), 190
Minnamurra Falls, Kiama (1978), c. 70 ferns with common names
Mulgoa, Nepean River (1976), c. 320
Otford, South of Sydney (1965–66), c. 250
North Head, Sydney (1967), c. 250
Nortons Basin, Nepean River near Warragamba River junction (1971–76), c. 130
Royal National Park, Sydney (1960–72), c. 720 with family names
Royal National Park:
  Anise Falls track (1978), c. 300,
  Audley (1974–76), c. 220,
  Bola Creek (1970–78), 160,
  Bundeena to Marley Lagoon (n.d.), c. 250,
  Burning Palms, via Palm Jungle (1978), c. 250,
  Burning Palms, via Squeezeway (1978), c. 70,
  Costans Point (1977), c. 300,
  Curra Moor fire trail (1977), c. 150,
  Engadine Station to Engadine Falls (1970–76), c. 320,
  Flat Rock Creek (1979), c. 240,
  Governor Game Lookout to Garrawarra (1970–77), c. 350,
  Jibbon Lagoons (1970–78), c. 400,
  Kangaroo Creek (1965–70), c. 220,
  Lady Carrington Drive (1965–70), c. 280,
  Middle Rill to Garie Beach (1975), c. 50,
  Mowlee Ridge (1978), c. 200,
  National Park Station (1970–75), c. 300,
  Otford Lookout to Werong Beach (1978), c. 300,
  Palm Creek (1978), c. 200,
  Savilles Creek—Temptation Creek (1960–70), c. 350,
  Scientist Hut—Couranga Track (1970–76), c. 250,
  Stevens Drive to Curra Moors (1970–76), c. 200,
  The Basin (1974–76), c. 300,
  Uloola Track (1965–77), c. 450,
  Upper Causeway (1970), c. 120,
  Wattamolla to Curracurrang (1976–77), c. 270,
  Winifred Falls (1979), 270,
  Wises Track (1977), c. 200.
St Marys, northeast of railway station (1968–73), 243
The Woolwash, Campbelltown (1965–70), c. 200
Thirlmere Lakes National Park (1977), c. 210
Toongabbie Creek Reserve, Sydney (1965–70), 290
Towra Point, Sydney (1977), 158
Whispering Gallery, southeast of Albion Park (1977), c. 110
Wilsons Creek, south of Waterfall, Sydney (1971–76), c. 140

SC Jervis Bay (1971), c. 180, families given

NT Additions to Mt Kaputar list produced by National Parks and Wildlife Service of New South Wales, (1976), c. 150, families given
Barrington Tops National Park (Gloucester Tops area), (1970–78), c. 170

CT Blackheath, Blue Mountains (1965–77), 295, for 4 sites
Centennial Glen, Blackheath, Blue Mountains (1965), 214, for 7 sites
Kanangra–Boyd National Park (1970–77), 154
Lawson, Blue Mountains (1970–78), c. 270, for 2 sites
Robertson Nature Reserve (1978), 45

Valley of the Waters Reserve, Wentworth Falls, Blue Mountains (1979), c. 250
Wentworth Falls, Blue Mountains (1969–77), c. 300 for 4 sites

ST Kosciusko National Park (1970–76), c. 270

CWS Goonoo State Forest, North of Dubbo (1973–78), c. 140

51. Cunningham, G. M. & Milthorpe, P. L. (1981). The vascular plants of five exclosure sites in western New South Wales. *Cunninghamia* **1**, 23–34.

NWP, SWP, SFWP Four hundred and one species are listed under families for 5 exclosure areas near Cobar, Booberoi, Micabil, Sayers Lake and Trida.

52. Cunningham, G. M., Milthorpe, P. L. & Mulham, W. E. (1979). Plants which occur in north-western New South Wales between 29–30° S and 141–144° E. (Unpub.).

NFWP About 500 species are listed alphabetically under families.

53. Cunningham, G. M., Milthorpe, P. L., Mulham, W. E. & Leigh, J. H. (in press). *Plants of western New South Wales.* Government Printer, Sydney.

NWP, SWP, NFWP, SFWP About 2,000 species are listed, in major plant groups, under families, alphabetically by genera. Notes on habitat, growth habits, flowering period, distribution, uses, toxicity, are given together with photographs and drawings of plants.

54. Department of Public Works, New South Wales (1978). *Wyong shire sewerage scheme, landscape investigations of proposed treatment sites.* Vol. 1. Department of Public Works, New South Wales, Sydney.

CC Evaluation of 6 sites. Approximately 450 species listed for 6 sites under plant associations.

55. Doing, H. (1972). *Botanical composition of pasture and weed communities in the Southern Tableland region, south-eastern Australia.* CSIRO Austral. Div. Pl. Industr. Techn. Pap. No. 30.

ST Fifty-five pasture plant communities are based on phytosociological grouping. About 550 species are listed with dominance, abundance, country of origin, growth-form; structure given.

56. Everleigh, J. N. (compiled 1978?). A preliminary list of the plants of the Kinchega National Park. (Unpub.).

SFWP About 240 species are listed, arranged by family, common names and soil type given.

57. Earp, R. (1973). Guide to the plants of Blackbutt Reserve. *Hunter Natural History.* **5**, 55–75.

CC First published by Newcastle Flora & Fauna Protection Society (1962). Revision includes short description of vegetation structure, a list of 195 native species under major plant groups, in families, coded for growth forms, plus a key to all species. Locality map. New Lambton, Newcastle.

58. Fauna Protection Panel. (n.d.). *The flora of the Sir Edward Hallstrom Faunal Reserve, No.* 15. Fauna Protection Panel, Wildlife Service, Sydney.

CC About 240 species are listed under families within major plant groups, common names given. Muogamarra Nature Reserve, north of Sydney.

59. Fisher, H. J. & Timms, B. V. (1978). Ferns of the rainforest of the Liverpool Ranges. *Hunter Natural History.* **10**, 174–88.

NT An ecological survey of 12 rainforest areas relating fern distribution to rainfall, soil nutrients and topography. Twenty-three species are listed with common names, notes on distribution, abundance and habitat. Illustrations. Near Murrurundi.

60. Floyd, A. & Coveny, R. (1977). Mt Warning National Park, Murwillumbah. (Unpub.).

NC About 400 species are listed by family under growth-form headings with common names and abundance.

61. Forestry Commission (1978). *A species list from south-east New South Wales, compiled from multiple sources and collections by Forestry Commission of New South Wales Research Staff at Eden.* Forestry Commission of New South Wales, Sydney.

SC About 850 species are listed, alphabetically by genera under family, in major plant groups.

62. Forster, G. R., Campbell, Desnee, Benson, D. H. & Moore, R. M. (1977). *Vegetation and soils of the western region of Sydney.* CSIRO Austral. Div. Land Use Res. Techn. Mem. 77/10.

CC Land use assessment for recreational and scientific purposes, listing major plant species, under 5 formations, 9 subformations, 26 communities.

63. Fox, M. D. (1977). Ground orchids of the Seal Rocks open forest. *Hunter Natural History.* **9**, 68–73.

NC A list of 8 species found during spring with notes on vegetation, habitat, abundance, habit and fire history. Myall Lakes area.

64. Fox, M. D. (1981). Pattern in coastal open-forest. Ph.D. thesis, Macquarie University. (Unpub.).

NC Detailed notes on community structure, fire responses. One hundred and thirty-one species are listed in major plant groups. Vegetation maps. Myall Lakes area.

65. Harden, G. J. (1976). *Provisional flora list—Warrumbungle National Park.* National Parks and Wildlife Service of New South Wales, Sydney.

NWS About 600 species are listed, alphabetically by genera, under major plant groups, within families, common names given. Near Coonabarabran.

66. Harden, G. J. (1977). *Provisional flora list—Mt Kaputar National Park.* National Parks and Wildlife Service of New South Wales, Sydney.

NT About 400 species are listed, alphabetically by genera, in families, under major plant groups. Common names, some notes on habitat and localities given. Near Narrabri.

67. Henshall, T. S. (1969). Flora check at a dam-site on Tapio Station south-west New South Wales. *Sunraysia Naturalists Research Trust.* 6th *Report*, 47–50.

SFWP About 80 species are listed, alphabetically by genera under families and arranged in major plant groups. Common names given and exotics indicated. Mildura area.

68. Henshall, T. S. (1970). A checklist of Australian saltbush. *Sunraysia Naturalists Research Trust.* 7th *Report*, 14–53.

NSW A census of Australian saltbush species (Chenopodiaceae) recorded by states.

69. Henshall, T. S. (1973a). A new flora checklist for northwestern Victoria and southeastern New South Wales. *Sunraysia Naturalists Research Trust.* 10th *Report*, 6–38.

SFWP A check list of c. 1200 species for 5 general areas, alphabetically by genera under families, common names given.

70. Henshall, T. S. (1973b). Eucalypts of northwestern Victoria and south-western New South Wales arranged under the system of Pryor and Johnson (1971). *Sunraysia Naturalists Research Trust.* 10th *Report*, 46–7.

SFWP A list of 19 species and subspecies. Near Mildura.

71. Holmes, G. (1979). Preliminary survey of vegetation remnants and associated avifauna on basaltic soils of far North-Western Slopes. (Unpub.).

NWS One hundred species are listed for 10 localities between Yetman, Crooble and Graman on the far northwestern slopes, coded for abundance.

72. Hungerford, A., Ingram, K. & Hind, P. (1976–78). Green Scrub, Bilpin via Mountain Lagoon. (Unpub.).

CC About 130 species are listed, alphabetically by genera. West of Sydney.

73. Ingram, C. K. (1972). Check list of the flora of Mt Tomah. (Unpub.).

CT About 600 species are listed, alphabetically by genera under families, with common names, plus "Additions, deletions and amendments" containing about 60 changes. West of Sydney.

74. Ingwersen, F. (1976). *Vegetation of the Jervis Bay Territory.* Conservation Series No. 3. Department of the Capital Territory, Canberra.

SC Description of plant communities for 4 land units. Species listed in association tables ranging in size from c. 60–c. 120 species for c. 50 sites. Maps.

75. Ingwersen, F., Evans, O. & Griffiths, B. (1974). *Vegetation of the Ainslie–Majura Reserve.* Conservation Series No. 2. Department of the Capital Territory, Canberra.

ST Detailed study with descriptions of land units, plant communities, soils, land use and management. Ninety six species are listed in an association table. Canberra. Maps.

76. Jacobs, S. W. L. & Pickard, J. (in press). *Plants of New South Wales.* Government Printer, Sydney.

NSW A census of the Conifers, Cycads, Dicotyledons and Monocotyledons. Record based on conifer, cycad, dicotyledon and monocotyledon specimens held in National Herbarium of New South Wales. About 6000 species are listed under family and tabled for botanical subdivisions.

77. Johnson, L. A. S. (1953). Flora of Minnamurra Falls Reserve, New South Wales—preliminary census (Phanerogams only). (Unpub.).

CC Brief notes on vegetation units and method of recording of about 150 species, listed systematically under family, with abundance noted for 4 vegetation units, and coded for life-form (Raunkiaer system).

78. Johnson, L. A. S. (1960). Plants of Whispering Gallery, Jamberoo. (Unpub.).

CC About 150 species are listed under structural headings, with some handwritten annotations on habitat.

79. Johnson, L. A. S. & Briggs, B. G. (1965). Notes on vegetation at Kurnell Peninsula. (Unpub.).

CC A number of sites within six communities are described. Species mentioned in text. Locality map for sites. Sydney region.

80. Jones, D. & Logan, A. E. (1971). A field study of *Dipodium hamiltonianum* F. M. Bailey in southern New South Wales—Jocks Mountain Carabost, near Tumbarumba. *The Orchadian* 4, 2–6.

ST Habitat description with c. 50 species for 2 sites.

81. Jurjens, P. (1974). Species list site occurrence for Duri—Nundle—head of the Peel area. Part of M.A. Hons thesis, University of New England, Armidale. (Unpub.).

NWS About 450 species are listed, alphabetically by families. Authorities, life-form, life span, growth season, toxicity, record of previous occurrence and sites are given. Southeast of Tamworth.

82. Kennedy, J. (1975). Wattles: some indigenous acacias of the Upper Hunter District of N.S.W. *Australian Plants* **8**, 152–4.

CWS Forty-four *Acacia* species are listed for 3 units of the land system. Scone, Muswellbrook, Denman, Merriwa and Murrurundi area.

83. Larkum, A. W. D. (1976). Ecology of Botany Bay. 1. Growth of *Posidonia australis* (Brown) Hook. f. in Botany Bay and other bays of the Sydney Basin. *Austral. J. Mar. Freshwater Res.* **27**, 117–27.

CC Distribution of sea grasses in Botany Bay and other Sydney Basin bays. Four species are discussed. Sydney region.

84. Leigh, J. H. & Mulham, W. E. (1977). Vascular plants of the Riverine Plain of New South Wales and notes on distribution and pastoral use. *Telopea* **1**, 225–93.

SWP About 500 species are arranged by family, genus. Notes on habitat, locality, abundance, uses, palatibility and toxicity. Exotics indicated.

85. Lewis, W. (1976). A possible new species of *Acacia*. *Sunraysia Naturalists Research Trust*. 12th *Report*, 24–26.

SFWP An undescribed species of *Acacia* plus 28 other species are listed for the area. Indication as to flowering or not flowering at time of collection given. Near "Mallee Cliffs", southwest corner of New South Wales.

86. Logan, A. (1974). Terrestrial orchids on Galore Hill Nature Reserve. *The Orchadian* **4**, 109–10.

SWS Notes on geology, topography. Species mentioned in text with notes on habitat. Map. Sixty-five km west of Wagga Wagga.

87. Lyons, M. T., Brooks, R. R. & Craig, D. C. (1974). The influence of soil composition on the vegetation of the Coolac Serpentinite belt in New South Wales. *J. Roy. Soc. N.S.W.* **107**, 67–75.

SWS Chemical analysis of plants and soils showing association of the iron group of elements with plants. Nine major species excluding herbs and grasses are listed. South of Cootamundra.

88. McBarron, E. J. (1950–1970s). Short species lists compiled by authors (H.J.B. and D.H.B.) from register of personal herbarium of McBarron. The lists are alphabetic by genera; family, date of collection and collection number are given. Number of species follows locality. (Unpub.).

CC Freers Crossing, Campbelltown, 39
Picton Lakes, Thirlmere, 136
Razorback, 87
Rookwood Cemetery, Sydney, 225
The Woolwash, Campbelltown, 136
Yellow Rock Creek area, Albion Park, 320

CT Hilltop, 84

89. McBarron, E. J. (1978). Floriculture of the 1920s Lysaght home, Cordeaux Street, Campbelltown. (Unpub.).

CC Brief history. An annotated list of 64 cultivated species, alphabetically by genera under growth-form headings, family and common name given, collection number and country of origin.

90. McDonald, K. (1971). Checklist of the flora of the Redhead–Jewells Swamp Area (Newcastle). *Hunter Natural History* **3**, 284–9.

NC Brief description of communities and 210 species listed under family, with common names. Additions in *Hunter Natural History* **4**, 231 (1972), brings number of species up to 233. Newcastle area.

91. McDonald, K. (1972). Notes on the vegetation of Kooragang Island. *Hunter Natural History* **4**, 216–22.

NC Description of land system and plant communities. Species are listed for 14 plant communities with common names. Newcastle area.

92. McDonald, K., Dorman, H. C., Baxter, N. & Baxter, C. (1971). A second transect study in the Redhead district. *Hunter Natural History* **3**, 38–55.

NC Sixty four species are listed in a vegetation survey with notes on habitat. Newcastle area.

93. McDonald, K., Dorman, H. C., Baxter, N., Baxter, G. & Kuhn, R. (Compiled 1970). A study of the flora of the Jewells Swamp area (Redhead). *Hunter Natural History* **2**, 58–62.

NC A vegetation survey across 2 communities listing 94 species alphabetically under family, with relative abundance, habitat and whether flowering or fruiting. Newcastle area.

94. McDonald, K., McNair, D. & Offler, C. E. (1973). Wildflowers of Warrah Sanctuary. (Brisbane Water National Park, Central Coast, New South Wales). Provisional checklist of plant species. *Hunter Natural History* **5**, 214–20.

CC One hundred and six flowering plant species are listed under families, with common names. Near Gosford.

95. McNair, D. L. (1974). The genus *Eucalyptus*. *Hunter Natural History* **6**, 144–54.

NC, CWS Seventy-five eucalypts for the Hunter Valley are listed with common names. List compiled from R. Story (1963) *Supplementary notes on the vegetation of the Hunter Valley land systems.* CSIRO Austral. Div. Land Res. Reg. Surv. Techn. Memo. 63/1.

96. McVean, D. N. (1969). Alpine vegetation of the central Snowy Mountains of New South Wales. *J.Ecol.* **57**, 67–86.

ST Discussion of alpine floristics. Species are not listed but mentioned in text for a number of associations.

97. Maiden, J. H. (1902). List of plants growing without cultivation in the Outer Domain. *Annual Report for Botanic Gardens and Domains for Year* 1902, 29.

CC About 240 native species are listed, alphabetically by genus under families. Sydney.

98. Martin, Alison (compiled ? 1978). Floral species list for Leard and Vickery State Forests. (Unpub.).

NWS About 100 species are listed under major plant groups by families. Common names and authorities are given and exotic species indicated. Occurrences for Mt Kaputar, Warrumbungle National Park, Pilliga Scrub and Pilliga Nature Reserve are recorded. Near Boggabri.

99. Matthew, P. (1973). Flora of the Dharug National Park, New South Wales. (Unpub.).

CC A vegetation survey describing 7 communities, with geological notes and listing c. 400 species under family, with growth form and common names. An additional list gives another 30 species. North of Sydney.

100. Milthorpe, P. L., Cunningham, G. M., Lawrie, J. W. & Stanley, R. J. (1975). Check list for Fowlers Gap Station. (Unpub.).

NFWP Three hundred and forty-six species are listed alphabetically with common names. North of Broken Hill.

101. Moore, C. W. E. (1973). Some observations on ecology and control of woody weeds on mulga lands in northwestern New South Wales. *Tropical Grasslands* 7, 79–88.

NWP Discussion of management for area with a list of 24 species, alphabetically by genus under shrubs and grasses. Area 100 km northwest of Cobar.

102. Morris, A. (1966). *Plantlife of the West Darling.* Barrier Field Naturalists Club.

NFWP, SFWP About 630 species are listed under major plant groups within families with authorities, notes on habit, habitat, abundance, common names and localities.

103. Mulham, W. E., Milthorpe, P. L. & Cunningham, G. M. (1978). Check list for Sturt National Park. 29–29° 30′ S and 141–142° 30′ E. (Unpub.).

NFWP About 450 species are listed under family with common names, growth-form and life span. Near Tibooburra.

104. Petersen, G. (1909). List of specimens collected at Cooks River. (Unpub.).

CC Sixty-four species are listed. Sydney region.

105. Pickard, J. (1973). Environmental impact statement. Wyee Channel. (Unpub.).

CC Description of 11 plant communities with species lists, divided into growth-form. Near Morisset.

106. Pickard, J. (1973). Vegetation survey and taxonomic lists for The Coal Cliff Collieries Pty. Limited Properties at Madden Plains, New South Wales. In *Submission to Illawarra Escarpment Inquiry.* The Coal Cliff Collieries Pty. Ltd. June, 1973.

CC About 170 species are listed under major plant groups within families. Descriptions for 10 vegetation units are given. Vegetation sketch map. North of Wollongong.

107. Pickard, J. (1974). Report on saline swamp—Calna and Berowra Creeks. (Unpub.).

CC Geomorphology and seral stages of swamp and importance on regional basis are discussed with four communities described. Eighty-two species are listed alphabetically by family for 4 sites. Sydney region.

108. Pickard, J. & Benson, D. H. (1975). Report on vegetation: Warkworth Coal Tender Area No. 1. (Unpub.).

NC Brief description of 6 vegetation units listing 69 species, alphabetically by family for 4 sites. Near Singleton.

109. Price, G. A. (1979). The vegetation of Duck River and Rookwood Cemetery, Auburn (with a list of species). (Unpub.).

CC Topography, soils, hydrology and history of settlement are given with descriptions of plant communities. About 430 species are listed for 2 sites divided into 8 units. Species are in major plant groups under families, abundance classes, with exotics indicated. Sydney region.

110. Purdie, R. W. & Slatyer, R. O. (1976). Succession after fire in sclerophyll woodland. *Austral. J. Ecol.* **1**, 223–36.

ST Dynamics of vegetation regeneration after fire. A list of about 90 species, alphabetically by genus in growth-form groups. Black Mountain near Canberra.

111. Purdie, R. W. (1977). Regeneration of dry sclerophyll vegetation after burning. *Austral. J. Bot.* **25**, 21–34.

ST Dynamics of vegetation regeneration 2 summers after burning. A list of about 70 species, alphabetically by genus in growth-form groups. Black Mountain near Canberra.

112. Riddell, J. (Revised 1974). A list of plant species in Ku-ring-gai Chase National Park based on "A census of trees and plants in Ku-ring-gai Chase" by O. D. Evans, 1959. With additional observations by D. F. Blaxell, W. E. Westman, T. S. Barratt, A. B. Rose, compiled by A. B. Rose, 1969. (Unpub.).

CC A list of 975 species, under family, with common name, locality, growth-form and habitat. Sydney region.

113. Riepon, J. (1979). Orchid list for Gibraltar Range National Park and Washpool State Forest. (Unpub.).

NC About 360 species of Orchidaceae are listed for 17 localities around Grafton, locality maps plus flowering times given.

114. Robertson, C. C. (1926). *The trees of extra-tropical Australia. A reconnaissance of the forest trees of Australia from the point of view of their cultivation in South Africa. A report of a tour in Australia in* 1924. Forest Department, Pretoria.

NSW Descriptions of the forests of each state, divided into natural divisions. No list, tree species mentioned in text.

115. Rodd, A. N. (1974). Checklist of angiosperms. In *Environmental survey of Lord Howe Island* (Eds. H. F. Recher & S. Clark), pp. 21–25. Government Printer, Sydney.

LHI A list of about 400 species, alphabetically by genus under family with authors and common names. Exotic and endemic species indicated.

116. Rodd, A. N. & Benson, D. H. (1977). Garden Island Dockyard—botanical survey. (Unpub.).

CC Short description of areas where native species persist. A list of 24 species for 3 areas. Sydney region.

117. Rogers, R. W. & Lange, R. T. (1972). Soil surface lichens in southeastern Australia. *Austral. J. Bot.* **20**, 215–27.

NWP, SWP, NFWP, SFWP Study of floristics and distribution of soil surface lichen flora of sub-arid southeastern Australia, including western half of New South Wales. An annotated list of 42 taxa.

118. Rose, A. B. (1970). Flora and fauna of North Wahroonga bushland. (Unpub.).

CC Five vegetation units are described. About 380 species are listed under major plant groups within families, coded for vegetation units, with common names given. Sydney region.

119. Sainty, G. R. & Jacobs, S. W. L. (in press). *Waterplants of New South Wales.* Water Resources Commission, Sydney.

NSW About 200 species are listed alphabetically by genus within family. Generic keys to all aquatic plants, species keys to all except sedges and grasses. Brief description of habitat, growth biology and distribution.

120. Semple, W. S. (1979). Species list—Mallee Cliffs. (Unpub.).

SFWP About 150 species are listed alphabetically with common names. North of Wentworth.

121. Shipway, C. H. (1972). Some ferns of Gap Creek Reserve. *Hunter Natural History* **4**, 289–97.

CC Description and illustrations of 34 ferns with common names. Wattagan Mountain, northwest of Wyong.

122. Siddiqi, M. Y., Carolin, R. C. & Anderson, D. J. (1972). Studies in the ecology of coastal heath in New South Wales. Part I. Vegetation structure. *Proc. Linn. Soc. N.S.W.* **97**, 211–24.

CC Study of structure of heathland, listing c. 100 species. Mourawaring Point near Gosford, New South Wales.

123. Siddiqi, M. Y., Carolin, R. C. & Myerscough, P. J. (1976). Studies in the ecology of coastal heath in New South Wales. Part III. Regrowth of vegetation after fire. *Proc. Linn. Soc. N.S.W.* **101**, 53–62.

CC Floristic changes after fire, listing c. 50 species occurring commonly, and c. 100 occurring less commonly. Mourawaring Point, near Gosford.

124. Simon, B. K. (1978). *A preliminary check list of Australian grasses.* Botany Branch, Department of Primary Industry, Brisbane, Techn. Bull. No. 3.

NSW About 1 700 species are listed by tribe, sub-tribe, genus, species and subspecies, with authorities given, for all states of Australia. States, habit are coded.

125. Smithers, C. (1978). A preliminary list of the ferns of Tuglo Wildlife Refuge. *Hunter Natural History* **10**, 189–91.

NC Thirty-eight species are listed, under family, with common names and authorities. Area 49 km north from Singleton to Mount Royal State Forest.

126. Thompson, J. (1968–1970s). List of plants collected in the Brewarrina area. (Unpub.).

NWP A list of c. 180 species arranged in families with localities and habitat notes.

127. Thompson, J. & Gray, M. (in prep.). A check list of the flora of subalpine and alpine Kosciusko district.

ST A list of c. 400 species arranged alphabetically by families. Covering an area from The Pilot to Happy Jacks Plain.

128. Timms, B. V. (1972). The freshwater lagoon, Myall Lakes National Park. *Hunter Natural History*, **4**, 6–10.

NC Description of ecology of lagoon, mentioning five species of water plants.

129. Timms, B. V. (1975). The wildflowers of the Red Gum Forest. *Hunter Natural History*, **7**, 153–61.

CC Observations of plant community over a year. Forty-five species are listed under major plant groups, in families. Flowering period noted. Northern end of North Entrance Peninsula, Norah Head and Toukley.

130. Timms, B. V. (1978). Wildflowers of Somersby, via Gosford. *Hunter Natural History* **10**, 140–44.

CC A listing of 108 species with abundance, flowering season and habitats noted.

131. Timms, B. & Timms, B. (1977a). Ferns of Myall Lakes National Park. *Hunter Natural History* **9**, 74–88.

NC Alphabetical check list of 27 species with habitat, abundance, habit, common name and locality map.

132. Timms, B. & Timms, B. (1977b). Ferns seen on the N.S.S.P.S. Easter Camp at Upper Carrowbrook. *Hunter Natural History* **9**, 114–17.

NC A listing of 35 species with distribution, abundance, habitat, localities, plant community, common name and locality map. South of Barrington Tops.

133. Turner, J. C. (1976a). An altitudinal transect in rainforest in the Barrington Tops area in New South Wales. *Austral. J. Ecol.* **1**, 155–74.

NT Measurement and analysis across an ecotone, recording tree, vine and tree-fern species. A list of 58 species, alphabetically by family.

134. Turner, J. C. (1976b). Vegetation of the Brushy Hill Range, Lake Glenbawn. *Hunter Natural History* **8**, 234–44.

CWS Description of vegetation. Abundance and distribution patterns for 15 woody species are discussed. East of Scone.

135. Upper Middle Harbour Conservation Committee. (1974). *Bantry Bay—the case for conservation.* Upper Middle Harbour Conservation Committee.

CC Environmental survey, with recommendations for conservation and management. A list of c. 160 species for 3 communities, alphabetically by genus under family, within major plant groups. Common names. Sydney region.

136. Walker, J. (1973). The Sydney orchids. *The Orchadian.* **4**, 82–4.

CC A list of 95 species for Sydney region compiled from H. M. R. Rupp (1943) *Orchids of New South Wales.* National Herbarium of New South Wales, Sydney. Year of first collection and locality given.

137. Ward, J. E. & Ingwersen, F. (1978). *A checklist of vascular plant species in the Australian Territory of Jervis Bay.* Conservation Memorandum No. 7. Conservation and Agriculture Branch, Department of the Capital Territory, Canberra.

SC About 300 species are listed in major plant groups under families, introduced species asterisked.

138. Ward, J. E. & Ingwersen, F. (1979). *A checklist of vascular plant species in the Tidbinbilla Nature Reserve.* Conservation Memorandum No. 8. Conservation and Agriculture Branch, Department of the Capital Territory, Canberra.

ST About 320 species are listed alphabetically under major plant groups, within families, with authorities, common names given, exotics indicated.

139. Waterhouse, D. (1975). The natural history of Bow Wow Gorge. *Hunter Natural History* **7**, 208–12.

NC Description of 3 plant communities. Species mentioned in text with common names, in canopy, understorey and ground layer categories. Locality map. Near Taree.

140. Waterhouse, J. T. (1969). Bola Creek—Royal National Park. Census of woody angiosperm species. (Unpub.).

CC About 60 species are listed alphabetically by genera under families, authorities given. South of Sydney.

141. Waterhouse, J. T. (n.d.). Rainforest species at Mt Kiera. (Unpub.).

CC About 100 species are listed alphabetically by genera under families, authorities given. Annotated for epiphyte, herb, liane, parasite and exotic. Near Wollongong.

142. Waterhouse, J. T. & Benson, D. H. (1974). List of species recorded from Ludovic Blackwood Memorial Sanctuary, Beecroft. (Unpub.).

CC A list of 98 species divided into major plant groups and arranged by family. Exotic species indicated. Sydney region.

143. Waterhouse, J. T. & Quinn, C. J. (1974). Report on the flora of the site for the proposed power station at Eraring, New South Wales. (Unpub.).

CC About 130 species are listed for the 6 vegetation units described. Lake Macquarie, south of Newcastle.

144. Williams, J. B. (1976). *Flora of Gibraltar Range National Park. A check list of the vascular plants.* University of New England, Armidale.

NC Check list covering 3 formations divided into major plant groups. A list of c. 450 species under family, alphabetically by genus, common names, habitats. West of Grafton.

145. Williams, J. B. (1976). *The flora of the New England National Park. A general list of the vascular plants, recorded under major vegetation subforms.* University of New England, Armidale.

NC A check list divided into 8 vegetation subformations with short notes. A list of c. 600 species, alphabetically by genus under family, authorities and common names given. East of Armidale.

146. Williams, J. B. (1979). *A check list of the rainforest flora of New South Wales. Part 1—Trees and Shrubs. Part 2—Climbers.* Department of Continuing Education and Department of Botany, University of New England, Armidale.

NSW About 600 species are listed under families within genera, with authorities, common names, habit, southern limit for 5 types of rainforest—subtropical, warm temperate, cool temperate, dry, and littoral.

147. Williams, J. B. (1971, revised 1979). The littoral rainforest at Port Macquarie, New South Wales. (Unpub.).

NC Brief description of extent of vegetation unit, soils, rainfall. About 130 species are listed alphabetically under structural headings, under major plant groups, within families, common names given, plus some notes on habit, habitat, abundance.

148. Williams, J. B. & Harden, G. J. (1979). *The vegetation and flora of Brunswick Heads, New South Wales. Field notes and flora list.* University of New England, Armidale.

NC Description of one mangrove and four rainforest communities with a list of about 300 species under major plant groups within families. Vegetation sketch map.

149. Willis, J. H. (1979). Vascular flora of wildflower reserve at Cooma North, New South Wales. (Unpub.).

ST A list of c. 200 species under major plant groups, within families. Exotic weed species, abundance, localities noted.

ACKNOWLEDGMENTS

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Cunninghamia 1 (1): 79–113 (1981)

VEGETATION SURVEY OF BRISBANE WATER NATIONAL PARK AND ENVIRONS

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ABSTRACT

Benson, J. S. and Fallding, H. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia* 2000) 1981. *Vegetation survey of Brisbane Water National Park and Environs. Cunninghamia* 1 (1): 79–113. The vegetation of Brisbane Water National Park and environs is described and mapped at a 1:50 000 scale, using air photo interpretation and ground survey. Fifteen plant communities are described in detail. The number of communities reflects the diversity of the region; this is mainly determined by physical factors such as geology, topography and proximity to the sea. 657 plant species are recorded. Ten species are considered to be rare or at risk and several others are uncommon or restricted in distribution.

INTRODUCTION

The Sydney region is floristically rich and varied. Some plant habitats however are very localized, and many species show very restricted distribution patterns. With the continuous exploitation and clearance of natural vegetation for development the National Parks and nature reserves of the area become ‘islands’ in a sea of altered habitats. They may be the only areas where representative samples of ecosystems can be preserved and rare species protected. The Brisbane Water National Park and its adjacent relatively undisturbed bushland areas provide an excellent example of the vegetation typical of coastal areas of the Sydney region. The present account arises from a vegetation survey undertaken at the request of the New South Wales National Parks and Wildlife Service to provide basic information on the vegetation of the region. The aims of the survey were firstly, to describe the plant communities in the region and discuss their distribution and importance, and secondly, to study species composition and distribution and identify the uncommon and rare species requiring protection or particular types of management.

THE STUDY AREA

The Brisbane Water National Park, (lat. 33° 30′ S, long. 151° 15′ E) is an area of c. 7 800 ha, 40 km north of Sydney. The survey also covered extensive areas of natural vegetation of the upper Mooney Mooney Creek catchment (c. 3 000 hectares in area) directly north of Brisbane Water National Park, and the Strickland State Forest (474 hectares) north-east of the Park (Figure 1).

Climate

The area receives an annual rainfall of about 1 250 mm, with a relatively wet season between January and June, during which about 60% of the annual rainfall is received. March is the wettest month, with a mean monthly rainfall of 147 mm, while October is the driest, with a mean monthly rainfall of 76 mm (data for Gosford, Bureau of Meteorology, 1979). Temperatures in the area are fairly mild, with an average maximum of 27° C in summer and 17° C in winter. Average minimum temperatures range from about 17° C in summer to 4° C in winter.

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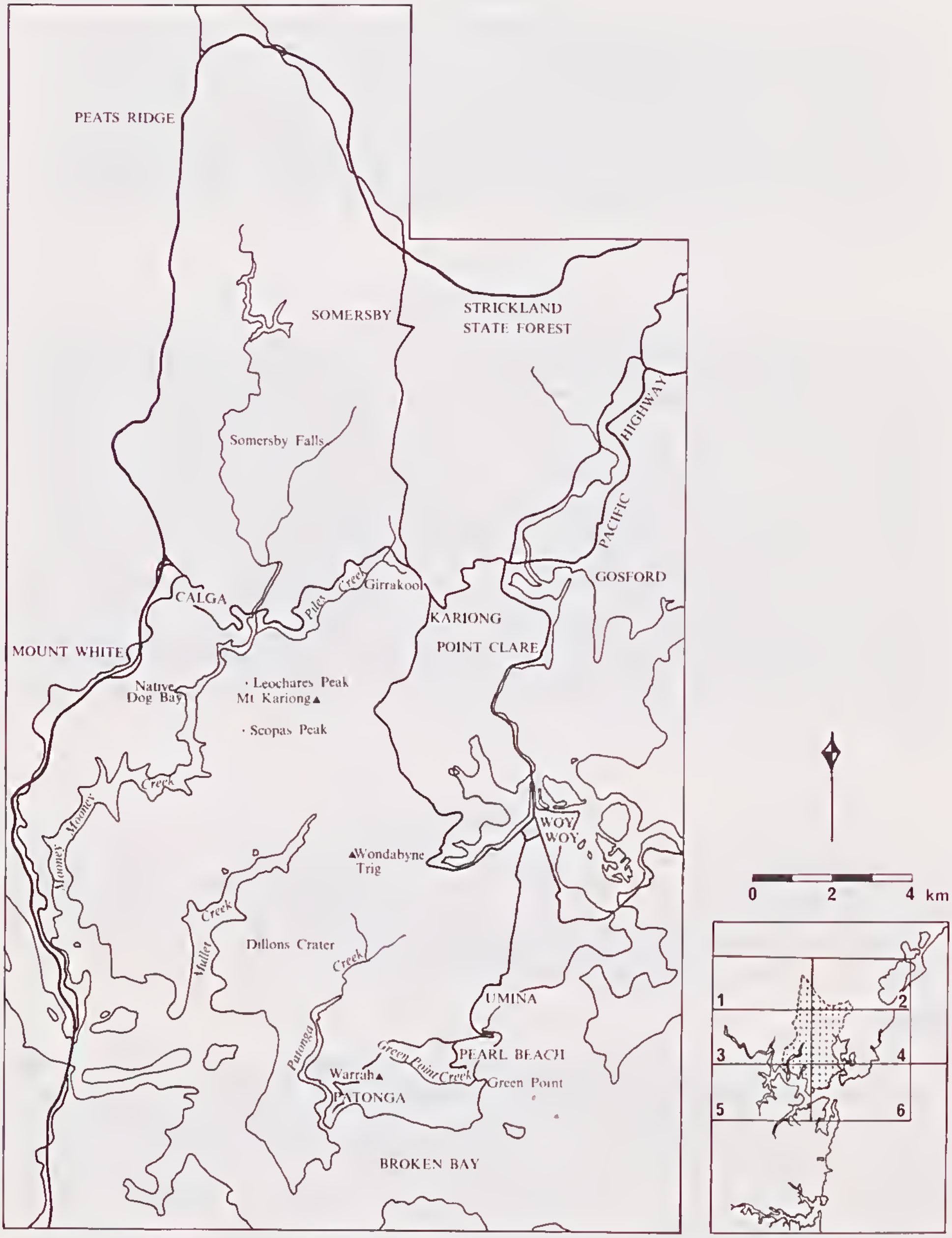

Figure 1. Locality map of Brisbane Water National Park and environs. Inset shows Lands Department 1:25 000 topographic sheets: 1 = Mangrove, 2 = Wyong, 3 = Gunderman, 4 = Gosford, 5 = Cowan, 6 = Broken Bay.

The most frequent winds throughout the year are light southerly to southwesterly and northeasterly. On-shore winds predominate during the spring and summer, while westerly and northwesterly winds occur mainly in autumn and winter. Local and low pressure frontal storms, particularly from the southeast in summer, bring gale-force winds.

Topography, geology and soils

The study area is part of the Triassic Hawkesbury Sandstone plateau which covers much of the Sydney region (New South Wales Dept. of Mines, 1966). During its uplift this plateau was dissected by deep valleys which cut through the Hawkesbury sandstone to expose the underlying strata of the Narrabeen Group, also of Triassic age. The lower sections of these valleys have been subsequently drowned by rising sea level to give the present shallow estuaries of Mooney Mooney and Mullet Creeks. Stream patterns on the sandstone plateaux are dendritic but are influenced by the jointing patterns in the sandstone. Valley profiles are typified by cliffs of the more resistant Hawkesbury Sandstone, steep slopes (with angles of ca. 25°) from the underlying Narrabeen Group and narrow valley floors or drowned river valleys. More resistant remnants of sandstone form higher peaks on the plateaux, such as Kariong and Wondabyne Trigs. The Hawkesbury Sandstone is composed mainly of lenticular beds of quartz-rich sandstone, with occasional shale and siltstone lenses (Standard in Packham, 1969). A variety of soil types is found. On ridges and slopes, soils vary from shallow skeletal siliceous sands to deeper duplex soils with a sand to sandy loam A horizon, and a sandy clay to medium clay B horizon. On ridges in the south of the Park, exposed shale lenses weather to light clay soils with gradational profiles. On plateaux (particularly in the north) distinctive yellow earthy soils are developed. These have gradational profiles and often are associated with ironstone nodules.

The Narrabeen Group, composed in this area mainly of shales, underlies the Hawkesbury Sandstone. Exposures of Narrabeen Group vary, reaching a maximum in Strickland State Forest and Mooney Mooney Creek in the north, and decreasing to the south of the study area near Patonga. These rocks form deep clay-rich soils with duplex to gradational profiles.

Small intrusions of Tertiary basaltic rock are found at Dillons Crater and the Woy Woy rubbish tip in the southeast of the study area. These intrusions weather to deep dark clay soils (rich in iron and magnesium) with gradational or uniform profiles.

Quaternary and Recent deposits of unconsolidated sands and silts occur along the major watercourses, e.g. Mooney Mooney Creek.

Land use and human influences

Attempts at agriculture in the Brisbane Water area were begun in the 1820's but proved unsuccessful and were replaced by timber getting and boat building. These remained the major industries into the 20th century when they were replaced by tourism and recreation, and increasing urbanization (Strom *et al.*, 1979).

In the Park there has been past logging activity, particularly along Mooney Mooney and Piles Creeks. Sand extraction on the banks of Mooney Mooney Creek, upstream from the Pacific Highway bridge, no longer occurs, but was formerly extensive.

The southern half of the Park has various 'incursions', private holdings, such as quarries, farms, a rifle range and a National Fitness Camp. Quarrying for sandstone is still active in the Girrakool-Kariong area, but not within the Park.

The main northern railway passes through the Park, along the eastern bank of Mullet Creek and through a long tunnel to Woy Woy. A large settlement (several hundred people) existed in the area above the tunnel during the construction of the railway in the 1880's. Several major roads pass through the study area: the Pacific Highway from Calga to Kariong and Gosford, and a main road from Kariong to Woy Woy. The Sydney to Newcastle Freeway forms the western boundary of the Park. A number of fire trails and walking tracks have been constructed within the Park.

In the east, the coastal flats along Brisbane Water have been almost entirely developed for residential purposes and both north and south of Gosford urbanization is extensive. Kariong, Calga and Somersby are small settlements on the boundaries of the Park. The northern catchment of Mooney Mooney Creek is bounded to the west and east by farms and quarries. Since many creeks originate in this area the catchments have been and will continue to be affected by this type of land use. Two dams have been built on Mooney Mooney Creek, as part of Gosford's water supply.

Strickland State Forest was the site of the first Australian Forestry School but it only lasted a few years, until the National Forestry School was set up in Canberra in 1925. The trees of *Araucaria bidwillii* (Bunya pine) planted in the Forest are remnants of an arboretum. The forest is now being managed as a reserve, with no logging.

METHODS

Colour aerial photography (New South Wales Dept. of Lands, 1976, Gosford-Newcastle Project Misc. 971. Scale 1:25 000) was used for the initial recognition of plant community boundaries. Field work was carried out to check the community boundaries and to determine the composition and variation in communities recognized. Vehicle traverses were made along almost all vehicular tracks in the area. Additional traverses were made on foot.

Plant communities were classified on structure and floristics. Initial classification was by structure (according to Specht, 1970), though the gradational nature of much of the vegetation made clearcut distinctions impossible. Some communities therefore include considerable variation in structure (e.g. low open-forest to open-forest). Where possible further subdivisions were made, based on floristic differences, which were generally associated with particular habitats. A structural floristic distinction based on a moist or dry shrub understorey was also used. A moist understorey is one with a strong species component of mesophyllous 'rainforest type' shrubs such as *Backhousia*, *Acmena* and *Rapanea*. A dry understorey is dominated by sclerophyllous shrubs such as *Oxylobium*, *Pultenaea* and *Dillwynia*. There is a gradation between the two types.

Field work involved recording lists of species for each of the communities, with observations on understorey structure, dominant species and effects of fire, disturbance, soil type and aspect.

The vegetation map was compiled using the New South Wales Department of Lands 1:25 000 topographic map series sheets Broken Bay, Cowan, Gosford, Gunderman, Mangrove and Wyong. This map has been reduced to a scale of 1:50 000 for publication.

THE VEGETATION

The types of vegetation present have been discussed in general terms in Pidgeon (1937, 1938, 1940, 1941). Fifteen plant communities have been recognized. The most common structural formations are low open-forest, low open-woodland and open-woodland with either dry or moist shrub understorey. These extend over the ridges and slopes on Hawkesbury Sandstone, which covers much of the total area. Open-forest communities are found on cooler aspects and on Narrabeen Group outcrops along the watercourses. More restricted communities include sedgelands and open-scrub in higher, poorly-drained locations, closed-forest with rainforest species in valleys or along creeks (mainly on the Narrabeen Group outcrops), mangroves (tall open-scrub) and reedland/rushland along tidal watercourses, coastal heath and rock outcrops with pockets of heath.

The distribution of the plant communities is shown on the map "Vegetation of Brisbane Water National Park and Environs" (located in back pocket).

Description of plant communities

Each plant community is described in terms of its structure, habitat and distribution, together with the main species present arranged in life-form groups. Any variation in structure or species composition related to variation in geology, topography, drainage, aspect, fire history etc. is discussed. A full species list for the area, together with species recorded for the different communities is given in Table 1.

The communities described are:

1. CLOSED-FOREST to LOW CLOSED-FOREST with emergent trees
2A. OPEN-FOREST—dry understorey, Narrabeen group
2B. OPEN-FOREST—moist understorey, Narrabeen group
3. OPEN-FOREST—coastal alluvial flats
4. OPEN-FOREST to LOW OPEN-FOREST—slopes on Hawkesbury Sandstone
4P. OPEN-FOREST to LOW OPEN-FOREST—plateau tops
4S. OPEN-FOREST—remnant shale outcrops
5. LOW OPEN-FOREST—coastal
6. LOW WOODLAND TO LOW OPEN-WOODLAND
7. TALL OPEN-SCRUB—Mangroves
8. CLOSED to OPEN-SCRUB
9. Rocky outcrops with pockets of HEATH
10. HEATH—coastal
11. REEDLAND/RUSHLAND with *Casuarina glauca* and *Melaleuca styphelioides*
12. SEDGELAND

Community 1 *CLOSED-FOREST to LOW CLOSED-FOREST with emergent trees.*

Structure: Emergent trees up to 30 m high; small trees 8–12 m high with a dense canopy cover; moist understorey of small trees, shrubs, ferns and herbs (Figure 2).

Habitat: Deep, moist valleys of varying geology but usually on the Narrabeen Group; cool, southern and eastern aspects.

Distribution: Along many of the watercourses in the area. The most extensive examples are at the northern end of Mooney Mooney Creek and in Strickland State Forest. The largest examples in the Park are along Piles Creek and near Dillons Crater. This community is found as far south as below Warrah Lookout.

Main species present:

Emergent trees: *Angophora floribunda, Eucalyptus deanei, Syncarpia glomulifera, Acacia elata.*

Small trees: Rainforest species such as *Backhousia myrtifolia, Acmena smithii, Ceratopetalum apetalum, Doryphora sassafras, Livistona australis.*

Shrubs: *Trochocarpa laurina, Tristania laurina, Notelaea* spp., *Wilkiea huegeliana, Eupomatia laurina.*

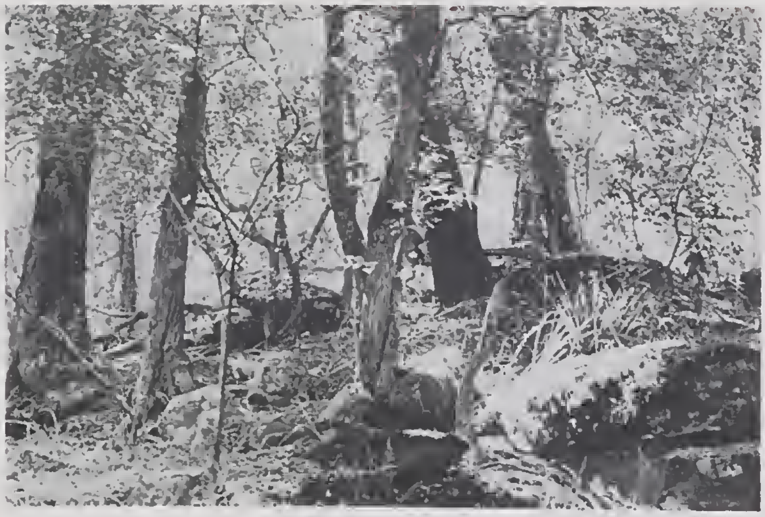

Figure 2. Low closed-forest with *Backhousia myrtifolia* (Community 1) near Mooney Mooney Creek.

Ferns: *Blechnum cartilagineum, Culcita dubia, Asplenium* spp., *Hymenophyllum cupressiforme, Doodia aspera.*

Others: Many climbers such as *Smilax* spp. and *Cissus* spp., herbs including orchids, other monocotyledons.

Comments: Variation is due to differences in geology, aspect, valley shape and size, and proximity to the sea. The Narrabeen Group outcrops support some species not found in the Hawkesbury Sandstone gullies further south, e.g. *Doryphora sassafras.* The species composition of the understorey appears to vary according to the amount of sunlight received.

Community 2A OPEN-FOREST with dry understorey on Narrabeen Group.

Structure: Trees 10–20 m high with a mid-dense to open canopy cover. Understorey varies from moist to dry (generally drier than Community 2B); mid-dense to sparse, mainly with shrubs, herbs and monocotyledons.

Habitat: Valley sides, dry northern or western aspects or slopes influenced by sea breezes. Usually on light clayey soils.

Distribution: Along the eastern escarpment of the Park from Warrah in the south to Point Clare in the north; eastern sides of Mooney Mooney and Mullet Creeks as far north as Calga.

Main species present:

Trees: *Angophora floribunda* and *Casuarina torulosa* are dominant. *Eucalyptus paniculata, E. punctata, E. resinifera, Callitris muelleri* may be associated in coastal areas.

Shrubs: *Dodonaea triquetra, Oxylobium ilicifolium, Persoonia* spp., *Pultenaea* spp., *Lasiopetalum ferrugineum* var. *ferrugineum, Dillwynia floribunda, Ceratopetalum gummiferum.*

Monocotyledons: *Themeda australis, Imperata cylindrica, Cymbopogon refractus, Xanthorrhoea arborea, Patersonia* spp.

Herbs: *Pomax umbellata*, *Dampiera stricta* in coastal areas.

Others: *Kennedia rubicunda*, *Cassytha* spp., *Glycine clandestina* (climbers), *Pteridium esculentum* (fern).

Comments: Variation is the result of fire history and differences in aspect; sheltered aspects have taller trees and moister understoreys. *Callitris muelleri* occurs in the south near Warrah but not to the north. Areas that have been frequently or recently burnt have ground cover dominated by *Imperata cylindrica* and *Pteridium esculentum*.

Community 2B *OPEN-FOREST with moist understorey on Narrabeen Group.*

Structure: Trees 10–30 m high with mid-dense canopy cover and moist understorey of varying density, comprising small trees, shrubs, herbs and monocotyledons.

Habitat: Valleys or on lower valley slopes, on clayey soils, often around pockets of closed-forest (Community 1).

Distribution: Widespread, but most common north of the Pacific Highway, in the Mooney Mooney Creek Catchment and Strickland State Forest. Also along Mullet Creek on cool, southeastern aspects.

Main species present:

Trees: *Eucalyptus deanei*, *E. acmenoides*, *Angophora floribunda*, *Casuarina torulosa*, *Syncarpia glomulifera*.

Shrubs: *Acmena smithii*, *Backhousia myrtifolia*, *Acacia prominens*, *Ficus rubiginosa*, *Rapanea variabilis*.

Ferns: *Doodia aspera*, *Culcita dubia*, *Pteridium esculentum*.

Monocotyledons: *Imperata cylindrica*, *Themeda australis*, *Lomandra* spp.

Herbs: *Hydrocotyle* spp., *Pomax umbellata*, *Schelhammera undulata*.

Others: Climbers such as *Hibbertia scandens*, *H. dentata*, *Cissus hypoglauca*, *Smilax* spp.

Comments: Variation is due to aspect, topographic situation, proximity to estuaries and fire history. There is a dense shrub cover where it surrounds pockets of closed-forest (Community 1) and also in the more constricted valleys north of the Pacific Highway. In these areas the incidence of fire is lower. In areas that have been frequently burned, e.g. along Mooney Mooney Creek near the Pacific Highway crossing, the understorey tends to be more open and dominated by *Pteridium esculentum* and *Imperata cylindrica*. Structure and composition change from north to south. In the upper Mooney Mooney Catchment the community tends to be taller and *Eucalyptus acmenoides* is common. Further south, tree height decreases and *E. acmenoides* disappears.

Community 3 *OPEN-FOREST—coastal alluvial flats.*

Structure: Trees up to 25 m high, mid-dense canopy cover. Understorey moist to dry with shrubs, monocotyledons and herbs.

Habitat: Coastal alluvial flats, cool aspects sheltered from strong winds by beachfront and foredunes. Soil sandy, deep, sometimes poorly-drained.

Distribution: Very restricted, being found behind Pearl Beach but nowhere within the Park; it may have been more widespread before urban development.

Main species present:

Trees: *Angophora floribunda*, *Eucalyptus maculata*, *E. botryoides*, *E. punctata*, *Livistona australis*.

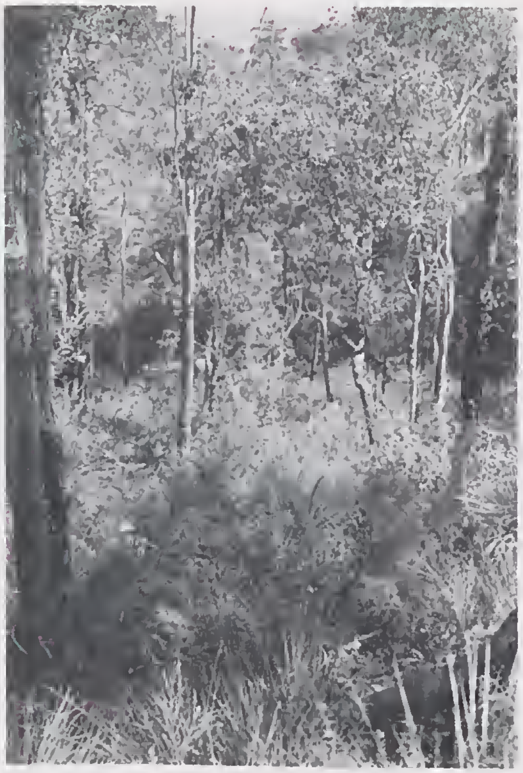

Figure 3. Open-forest on Hawkesbury Sandstone (Community 4) showing dense sclerophyllous shrub understorey.

Shrubs: *Macrozamia communis.*

Monocotyledons: *Imperata cylindrica*, *Pteridium esculentum*, *Goodenia* spp., *Hydrocotyle* sp.

Community 4 *OPEN-FOREST to LOW OPEN-FOREST—slopes on Hawkesbury Sandstone.*

Structure: Trees 8–25 m high; mid-dense canopy cover. Understorey usually dry, mid-dense to sparse with small trees, shrubs, dwarf shrubs, monocotyledons and herbs (Figure 3).

Habitat: On slopes below ridges or in shallow valleys draining the plateaux. Usually well-drained situations on slopes above Communities 2A and 2B, downslope from Community 6.

Distribution: Widespread throughout the study area, but more common in the south. In the north tends to grade into Community 4P on the plateaux.

Main species present:

Trees: *Angophora costata*, *Eucalyptus piperita* subsp. *piperita*, *E. oblonga*, *E. umbra* subsp. *umbra*, *E. gummifera*, *E. haemastoma*, *E. pellita.*

Small trees: *Banksia serrata*, *Casuarina littoralis*, *Tristania laurina.*

Shrubs: Diverse, including *Phyllota phylicoides*, *Petrophile pulchella*, *Dillwynia* spp., *Persoonia* spp. *Leptospermum* spp., *Acacia* spp., *Bossiaea* spp., *Pultenaea* spp. and various Epacridaceae.

Ferns: *Pteridium esculentum*, *Culcita dubia*.

Monocotyledons: *Entolasia stricta*, *Lepidosperma* spp., *Lomandra* spp., *Patersonia* spp., *Lepyrodia scariosa*, *Gahnia clarkei*, *Xanthorrhoea media*.

Others: Climbers such as *Cassytha* spp. and a variety of herbs.

Comments: Variation is due to aspect, fire history and drainage. Drainage changes caused by geology and topographic position influence species composition. In wet areas a moist scrub understorey (described as 4/8 on the vegetation map) is often found. This is dominated by *Banksia ericifolia* and *Hakea teretifolia* (see Community 8).

Creek banks are characterized by shrubs, *Tristania neriifolia*, *T. laurina*, *Baeckea linifolia*, *Callicoma serratifolia*, *Leptospermum flavescens*, *Logania albiflora*, *Lomatia myricoides*, *Phebalium dentatum*, *Ceratopetalum apetalum*, *Bauera rubioides*, ferns such as *Gleichenia* spp., *Todea barbara* and *Sticherus flabellatus* and climbers such as *Cassytha* spp. and *Smilax* spp. On dry aspects the understorey is sparse and consists mainly of members of the families Fabaceae and Proteaceae. Areas recently or frequently burned tend to have an open understorey dominated by monocotyledons and shrubs which have regenerated from lignotubers.

Community 4*P* *OPEN-FOREST to LOW OPEN-FOREST—plateau tops.*

Structure: Trees 10–20 m high with a mid-dense canopy cover. Understorey dry, mid-dense to dense, with tall shrubs, shrubs, monocotyledons and herbs (Figure 4).

Habitat: Plateaux on deep yellow earthy soils. The soils grade from a surface horizon of medium sand to a yellow sandy clay. The depth varies, but is usually 1 m deep; above Warrah Lookout on the Patonga road, it is at least 2 m deep and also noticeably more yellow.

Distribution: Restricted to plateaux. Within the Park, it is found near Warrah Trig in the south and near Kariong in the north. In the upper Mooney Mooney Creek catchment it is locally common northward from Somersby Falls. Formerly more widespread in the Somersby area but much of it has been cleared for orchards and grazing land.

Main species present:

Trees: *Angophora costata*, *Syncarpia glomulifera*, *Eucalyptus gummifera*, *E. haemastoma*, *E. sieberi*, *E. punctata*, *E. oblonga*, *E. capitellata*, *Banksia serrata*.

Tall shrubs and shrubs: *Leptospermum* spp., *Petrophile pulchella*, *Hakea* spp., *Acacia* spp., *Bossiaea* spp., *Lambertia formosa*, *Banksia spinulosa*, *Gompholobium* spp., *Persoonia* spp. Members of the Proteaceae are important e.g. *Telopea speciosissima*, *Xylomelum pyriforme*, *Grevillea* spp.

Monocotyledons: *Xanthorrhoea media*, *Lepyrodia scariosa*, *Tetrarrhena juncea*, *Patersonia* spp., *Lomandra* spp., *Doryanthes excelsa*, *Entolasia stricta*.

Herbs: *Actinotus minor*, *Dampiera stricta*, *Gonocarpus teucrioides*.

Comments: Variation is due to fire history, and soil and water-table depth. Areas to the north (Kariong to Mangrove Mountain Road) have shallower and less yellow soils than near Warrah in the south. *Doryanthes excelsa* is found only in the north. *Eucalyptus sieberi* is also more common in the north than the south; the other tree species are found throughout. On deeper soils and near watercourses the trees are taller.

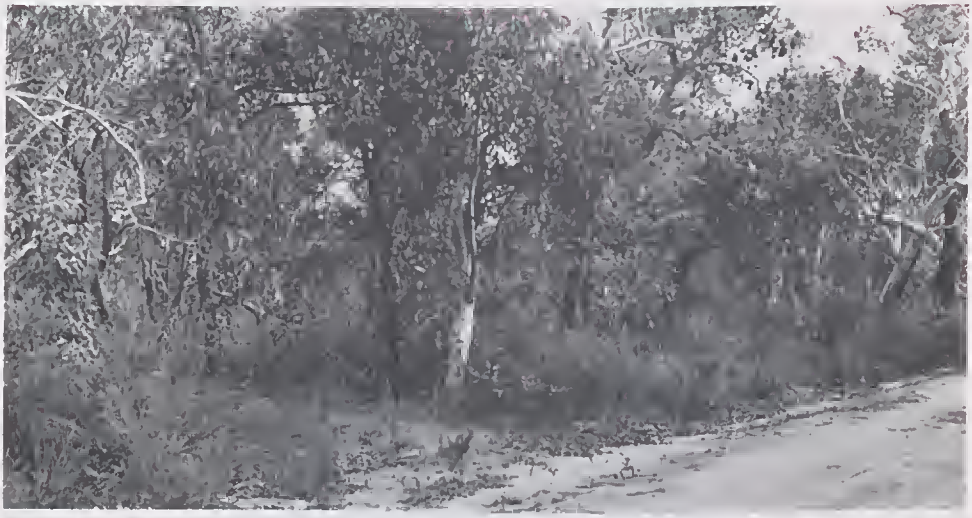

Figure 4. Low open-forest on Hawkesbury Sandstone plateau (Community 4P) with *Banksia serrata* and *Eucalyptus haemastoma*.

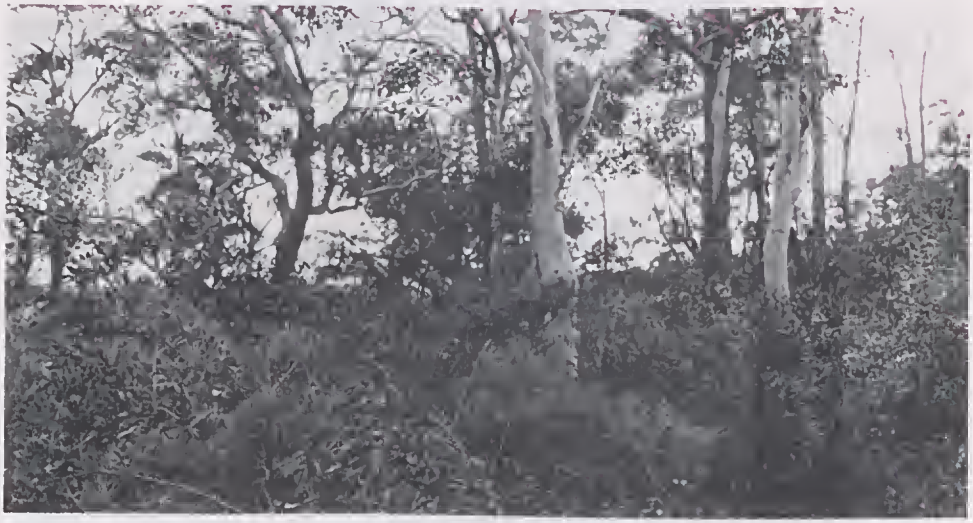

Figure 5. Open-forest on remnant shale outcrops (Community 4S). Trees include *Angophora costata* and *Eucalyptus globoidea*.

Community 4S OPEN-FOREST—remnant shale outcrops.

Structure : Trees 10–15 m high with a mid-dense canopy cover. Understorey dry, low, mid-dense to sparse; mainly shrubs and monocotyledons (Figure 5).

Habitat: Shale lense remnants on ridge tops. The soil profile shows a surface humus layerup to 2 cm deep, over a sandy clay loam 6 cm deep, which grades to a light clay.

Distribution: Restricted to patches at the southern end of the Park. The largest example is south of Mt Pindar near Wondabyne.

Main species present:

Trees: *Angophora costata*, *Eucalyptus gummifera*, *E. punctata*, *E. globoidea*, *E. umbra* subsp. *umbra*, *Syncarpia glomulifera*.

Shrubs: Dominated by members of the Fabaceae, *Bossiaea stephensonii*, *Gompholobium* spp., *Pultenaea ferruginea* var. *deanei* with *Acacia linifolia*, *Acacia myrtifolia*, *Banksia spinulosa*, *Boronia pinnata*, *Ceratopetalum gummiferum*.

Monocotyledons: *Poa affinis*, *Entolasia stricta*, *Imperata cylindrica*, *Lomandra* spp.

Comments: Variation is mainly due to fire history and soil depth. On deeper soils the trees are taller yet the understorey little changed. Fire alters the structure of the understorey but does not appear to affect greatly the floristic composition. This plant community is floristically distinct from other communities in the area. *Eucalyptus globoidea*, which appears to be restricted to it, is found on Wianamatta Shale near Sydney in areas with a similar rainfall.

Community 5 *LOW OPEN-FOREST—coastal.*

Structure: Trees stunted, usually about 5 m high; mid-dense canopy cover. Understorey mid-dense, varies with both "wet" and "dry" species of shrubs, monocotyledons and herbs.

Habitat: Narrabeen Group: coastal situations subject to onshore winds and salt spray; cooler aspects, on sloping well-drained ground.

Distribution: Restricted to the southern end of the Park near Pearl Beach. Common in nearby Bouddi National Park.

Main species present:

Trees: *Banksia integrifolia*, *Angophora costata*, *Eucalyptus botryoides*, *E. umbra* subsp. *umbra*.

Shrubs: *Lasiopetalum* spp., *Pultenaea daphnoides*, *Pultenaea flexilis*, *Westringia fruticosa*.

Monocotyledons: *Themeda australis*, *Lomandra longifolia*, *Imperata cylindrica*.

Climbers: *Cissus hypoglauca*, *Clematis aristata*, *Hardenbergia violacea*.

Comments: Tree height varies with exposure to wind and soil depth. Creeks running through this community are fringed by "wetter" species such as *Livistona australis* and *Cissus hypoglauca*.

Community 6 *LOW WOODLAND TO LOW OPEN-WOODLAND*

Structure: Trees 5–15 m (occasionally to 15 m) high with sparse canopy cover. Understorey varies from sparse and dry, to mid-dense and wet, with shrubs, dwarf shrubs, monocotyledons and herbs. Species richness is high (Figure 6).

Habitat: Ridges, spurs and slopes with dry aspects.

Distribution: Widespread in the south, less common in the forested north.

Main species present:

Trees: *Angophora costata*, *Eucalyptus gummifera*, *E. eximia*, *E. umbra* subsp. *umbra*, *E. haemastoma*, *E. punctata*.

Shrubs and Dwarf shrubs: Floristically rich, similar to Community 4 including *Banksia* spp., *Acacia* spp., *Hakea* spp., *Leptospermum* spp., *Boronia* spp., *Angophora hispida*; Fabaceae and Epacridaceae common.

Monocotyledons: *Entolasia stricta*, *Lepidosperma* spp., *Lepyrodia scariosa*, *Lomandra* spp., *Schoenus* spp., *Xanthorrhoea media.*

Comments: On rocky ridges with shallower soils, tree height decreases. The understorey varies with topography, drainage and fire history. On well-drained slopes the understorey is sparse, while on some backward sloping sandstone benches, where drainage is impeded, a wetter understorey is developed. As with Community 4, a mosiac of low open-woodland and closed to open-scrub is common. Like Communities 4, 4P and 13, the diversity and floristic composition may depend considerably on fire frequency and intensity. Small patches of the multistemmed "mallees" *Eucalyptus luehmanniana* and *E. multicaulis* are found within this community. They are usually on the cool, southerly aspects of the higher peaks, on sandstone rock shelves with shallow soils and poor drainage. Their distribution is very restricted. They are found in small isolated patches not more than a few hundred meters wide. *Eucalyptus luehmanniana* is on Mt Kariong and just north of Warrah Trig. *Eucalyptus multicaulis* is on the southern slopes of Leochares and Scopas Peaks.

Community 7 *TALL OPEN-SCRUB—Mangroves.*

Structure: Composed of tall shrubs of two distinct heights (8 m and 4 m), reflecting the two species present (Figure 7).

Habitat: Along tidal or on alluvial flats and islands subject to regular tidal inundation. Absent from areas exposed to wave action.

Distribution: Confined to the southern half of the study area: Mooney Mooney Creek, particularly downstream from the Pacific Highway bridge, Mullet Creek, Patonga Creek and other estuarine areas e.g. Woy Woy. Since the Park Boundary is defined in most areas as above the high tide mark, few, if any mangroves are actually located within the National Park.

Main species present:

Shrubs: *Avicennia marina* var. *australasica* forms open-scrub up to 8 m high with *Aegiceras corniculatum* as an understorey shrub about 4 m high, usually landward of *Avicennia.*

Comments: Differences of abundance and distribution between the two species depend on salinity, frequency of tidal inundation, wave action and sediment accumulation. The alluvial flats and islands have dense stands of *Avicennia* along the water's edge, but grade landward into scattered *Aegiceras* stands surrounded by reedland/rushland and *Casuarina glauca* woodland. Saltmarsh of *Sarcocornia quinqueflora* is only located at two sites on Patonga Creek. One of these has been severely damaged by trail bikes. In some areas increased sediment deposition has caused death of mangroves.

Community 8 *CLOSED to OPEN-SCRUB*

Structure: Shrubs 2–5 m high, dense to mid-dense, with a ground cover of monocotyledons (Figure 8).

Habitat: Associated with shallow, sandy, poorly-drained soils on a wide range of topography, including flat ridge tops and along drainage lines; often surrounding sedgeland. Frequently found as understorey in open-forest and low open-forest (Community 4).

Distribution: Widespread throughout the area.

Main species present:

Trees: *Eucalyptus haemastoma*, *E. umbra* subsp. *carnea*, *E. gummifera.*

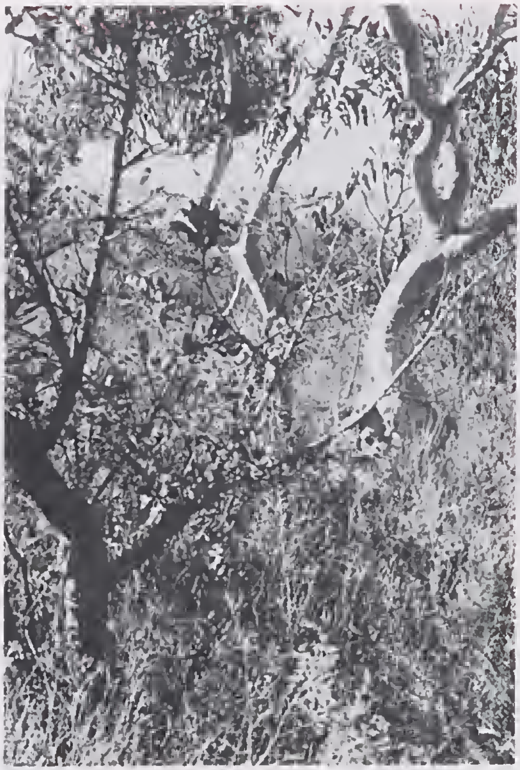

Figure 6. Low woodland on Hawkesbury Sandstone (Community 6) with *Eucalyptus haemastoma* and *Banksia serrata*.

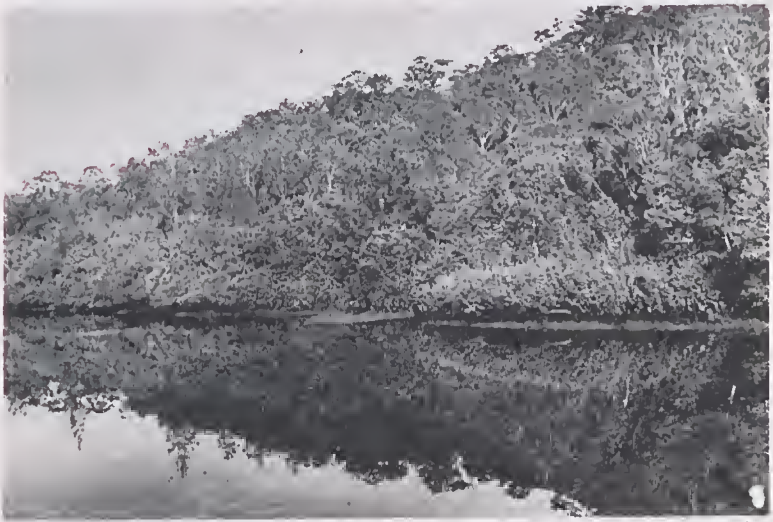

Figure 7. Fringe of tall open-scrub of mangroves, *Avicennia marina* (Community 7) along Mooney Mooney Creek, with open-forest behind.

Shrubs: *Banksia ericifolia* and *Hakea teretifolia* most common as dominants. Also other *Hakea* spp., *Acacia oxycedrus*, *Banksia aspleniifolia*, *Grevillea* spp., *Leptospermum* spp. and members of the Epacridaceae.

Monocotyledons: *Restio* spp., *Lepyrodia scariosa*, *Xanthorrhoea resinosa*, *Lomandra* spp.

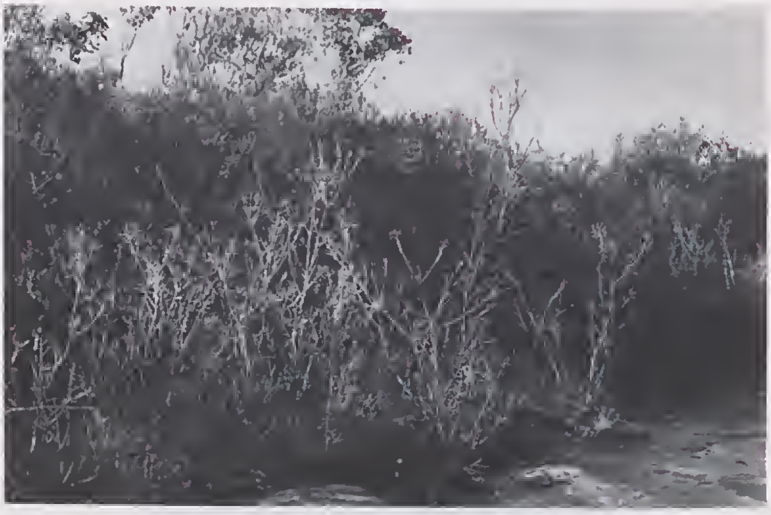

Figure 8. Closed-scrub of *Banksia ericifolia* (Community 8) surrounding small patch of *Callistemon sp.*

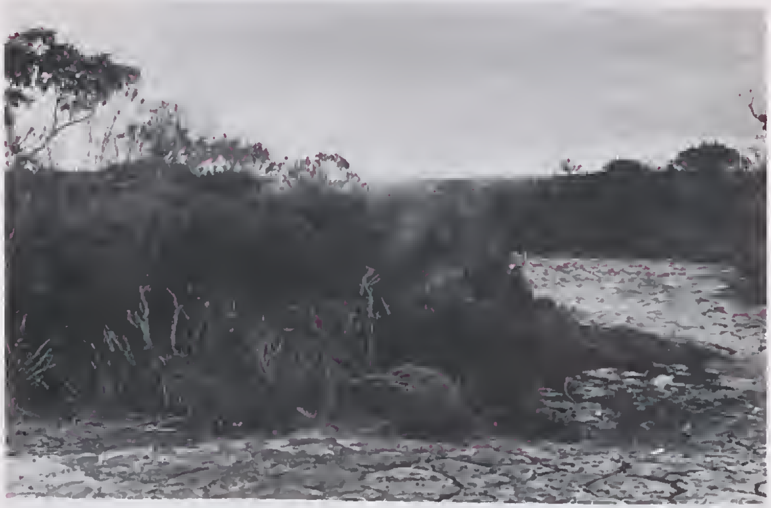

Figure 9. Rock outcrop with patches of *Kunzea ambigua* and *Casuarina distyla* (Community 9).

Comments: Variation is mainly due to drainage and fire history. A mosaic of communities (represented by 4/8 and 6/8 on the vegetation map) is formed by patches of trees on better drained, deeper soils. On poorly drained, organic soils, a transition zone between heath and sedgeland is found (8/12). Fire affects height and density of the heath. In places, unburnt for 15 years or more, height may reach 5 m.

Community 9 *ROCKY OUTCROPS with POCKETS OF HEATH*

Structure: Pockets of closed heath sometimes with low open-woodland on rock outcrops that generally comprises more than 50% of the cover (Figure 9).

Habitat: In isolated depressions, on rock platforms, on ridge tops and slopes on Hawkesbury Sandstone.

Distribution: Mainly found south of the Pacific Highway. Often associated with heath to low open-woodland. Restricted in area.

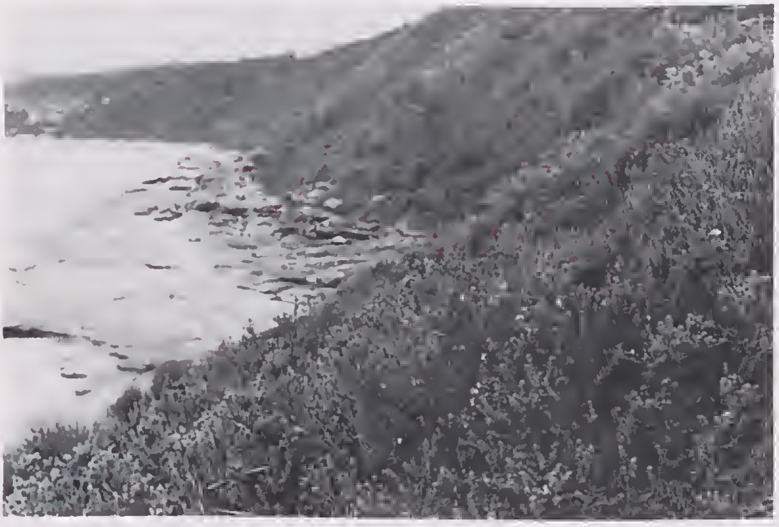

Figure 10. Coastal heath (Community 10) with *Westringia fruticosa* near Pearl Beach.

Main species present:

Trees: Scattered, often stunted or of mallee form. *Eucalyptus haemastoma*, *E. eximia.*

Shrubs: In pockets on the rock platform. *Casuarina distyla*, *Baeckea brevifolia*, *Darwinia fascicularis* subsp. *fascicularis*, *Darwinia glaucophylla* (which is mainly restricted to this community), *Eriostemon australasius*, *Kunzea ambigua*, *K. capitata*, *Leptospermum* spp., *Grevillea speciosa*, *Boronia serrulata*, *Banksia ericifolia*, *Epacris microphylla* and other Epacridaceae.

Monocotyledons: *Caustis pentandra*, *Lepidosperma laterale*, *L. limicola*, *Restio* spp.

Comments: Soil depth affects size of shrubs, though most areas of this community contain the characteristic species with little variation.

Community 10 *HEATH—coastal.*

Structure: Dense to mid-dense heath usually less than 2 m high with pockets of *Casuarina glauca* which reach 5 m high. On cliff margins where seepage occurs, a well developed herbaceous layer is found (Figure 10).

Habitat: Adjacent to the sea on slopes or cliff tops, extending down to the rock platforms. Subject to onshore wind and salt spray.

Distribution: Very restricted in Brisbane Water National Park. Found on Green Point near Pearl Beach. Common in nearby Bouddi National Park.

Main species present:

Trees: *Casuarina glauca*, *Banksia integrifolia.*

Shrubs: *Westringia fruticosa*, *Baeckea imbricata*, *Hakea gibbosa*, *Lasiopetalum macrophyllum*, *Leptospermum laevigatum*, *Pultenaea* spp.

Herbs: *Cotula longipes*, *Lobelia alata.*

Climbers: *Kennedia rubicunda*, *Stephania japonica* var. *discolor.*. Also exotic shrubs such as *Lantana camara* and exotic herbs, as a result of the close proximity to urban areas.

Comments: The community is taller where protected from wind. Fire may affect structure and species composition.

Community 11 *REEDLAND/RUSHLAND with* **Casuarina glauca** *and* **Melaleuca styphelioides.**

Structure: Two structural formations occur:

(i) REEDLAND/RUSHLAND: dominated by members of the Juncaceae (rushes) and Poaceae (reeds, grasses). Ground cover dense to mid-dense. Saltmarsh and salt couch sometimes present.

(ii) WOODLAND: *Casuarina glauca*, *Melaleuca styphelioides.* Trees up to 15 m high, mainly sparse canopy cover, with ground cover dominated by monocotyledons (Figure 11).

Habitat:

(i) REEDLAND/RUSHLAND: occurs on alluvial flats landward of the mangrove community, usually subject to frequent tidal inundation.

(ii) WOODLAND: *Casuarina glauca*, *Melaleuca styphelioides.* Along tidal channels on alluvial flats, on higher elevations (less saline?) than reedland/rushland but occasionally subject to tidal inundation.

Distribution: Often associated with mangrove communities in Mooney Mooney Creek, Piles Creek, Mullet Creek, Patonga Creek and lowland areas near Umina. On the whole, the community is restricted in area and, in the case of the developed coastal flats, is only a remnant of what originally existed. As with the mangrove community, most of this community is found outside the present Park whose boundaries are set at the high tide mark in most areas. Tidal channels or "backswamps" on the floodplain are dominated by reedland/rushland.

Main species present:

Trees: *Casuarina glauca*, *Melaleuca styphelioides.*

Shrubs: Uncommon, *Myoporum acuminatum*, *Acacia implexa.*

Monocotyledons: *Phragmites australis*, *Juncus kraussii* dominate in "boggy", saline areas. Others include *Baumea juncea*, *Agrostis avenaceus.*

Herbs: On higher, well-drained sand banks. *Viola hederacea*, *Gnaphalium* sp.

Comments: Variation is due to salinity changes and water-table depth. Different species require different saline conditions, e.g. *Juncus kraussii* is tolerant of strongly saline conditions, while *Phragmites australis* requires less saline conditions (Clarke & Hannon, 1970). These differences in saline tolerances are important in determining the relative distribution of these species.

Community 12 *SEDGELAND*

Structure: Dominated by monocotyledons, especially the families Cyperaceae and Restionaceae. Shrubs when present are scattered and less than 2 m high. No trees present (Figure 12).

Habitat: Occurs on swampy, organic soil often formed where impervious shale beds direct the water table to the surface. On plateaux or in shallow basins perched above the valleys.

Distribution: Found as patches of varying size, mainly from Kariong northwards. *Gahnia* swamps are restricted to drainage lines.

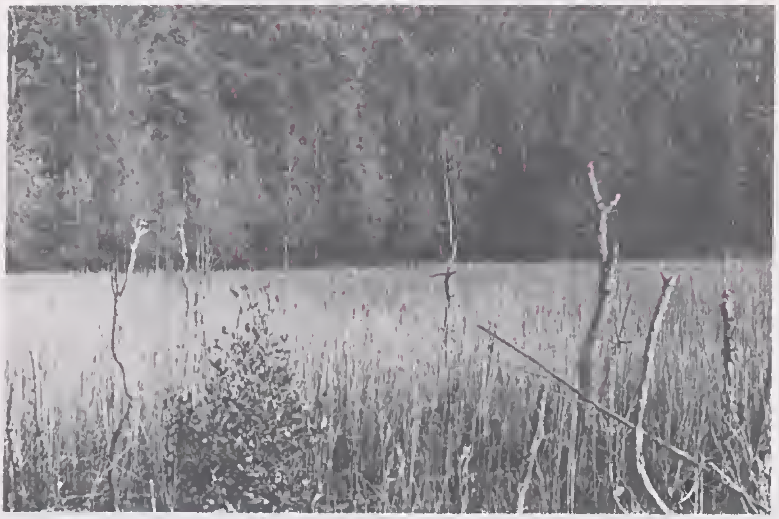

Figure 11. Rushland of *Juncus kraussii* with *Casuarina glauca* woodland in background (Community 11). Some mangroves in the foreground have been killed by nearby land reclamation which has altered the degree of tidal inundation.

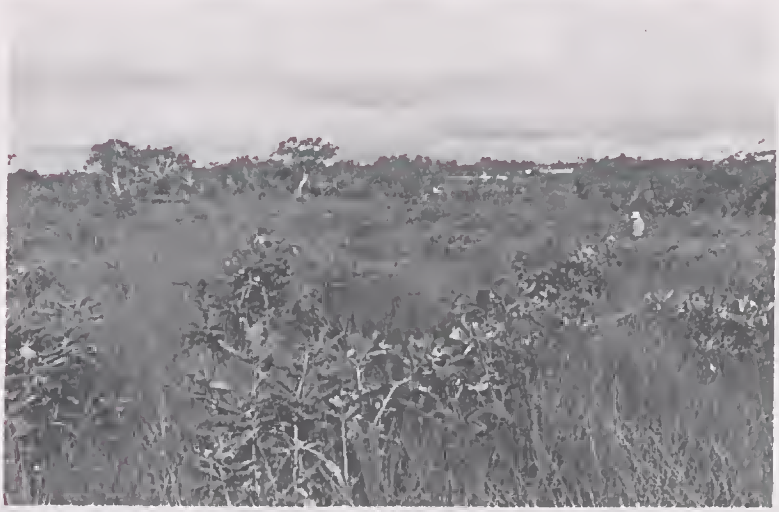

Figure 12. Extensive area of sedgeland (Community 12) with shrubs of *Banksia robur*.

Main species present:

Shrubs: *Banksia robur*, *Banksia ericifolia*, *Banksia aspleniifolia*, *Hakea teretifolia*, *Sprengelia incarnata*, *Leptospermum juniperinum*.

Monocotyledons: *Restio* spp., *Chorizandra* spp., *Cyathochaeta diandra*, *Gymnoschoenus sphaerocephalus*, *Lepidosperma* spp., *Leptocarpus tenax*, *Schoenus* spp., *Xanthorrhoea resinosa*, *Gahnia clarkei*.

Herbs: *Drosera* spp., *Dampiera stricta*.

Comments: Variation is due to drainage and fire history. In very waterlogged areas *Gahnia clarkei*, *Leptospermum juniperinum* and *Banksia robur* are dominant. In slightly better-drained areas are *Banksia robur* and *Gymnoschoenus sphaerocephalus*, while in drier areas again, *Banksia aspleniifolia* and *Xanthorrhoea resinosa* occur.

A transition between this community and Community 8 is usually present. The boundary of this zone may vary depending on the successional stage after fire (sedges to shrubs) and any changes in soil moisture levels.

DISCUSSION

Species Richness

Altogether 657 species have been recorded from the study area. This included 49 Pteridophytes, 3 Gymnosperms and 605 Angiosperms (426 Dicotyledons and 179 Monocotyledons). The high total number of species reflects the great variety of habitats in the region. The greatest species richness is in the shrub species (240 species) and among the Monocotyledons (179 species). The large number of tree species (49 including 20 *Eucalyptus* species) also gives a good indication of the variety of the canopy composition though most of the non-eucalypt species are restricted to closed-forest. The total number of species listed is about 75% of that recorded for nearby Ku-ring-gai Chase National Park (Riddell, 1969) which is very similar geologically, topographically and floristically to Brisbane Water. Almost certainly the number of species known to occur in Brisbane Water National Park will be increased, when more intensive collecting is undertaken, and the exotic species are taken more fully into account.

Rare and Restricted Species

A number of rare and restricted species have been recorded within the area studied, some of which are considered "vulnerable" or "endangered".* These may occur as small populations of sporadic localized occurrence distributed over a relatively wide geographical region, or as populations of very restricted distribution, in some cases being confined to the study area.

Species of sporadic occurrence but found over a relatively wide geographical area are:

Melaleuca deanei (Myrtaceae), a shrub found in the understorey of low open-woodland (Community 6). Recorded only from the South Coast and Central Coast of New South Wales with its presently-known northern limit within the Brisbane Water National Park.

Eucalyptus multicaulis (Myrtaceae), a mallee occurring in open-woodland or low open-woodland on rocky sandstone slopes. In the study area *E. multicaulis* is found only on the slopes of Scopas Peak and Leochares Peak. Although the Type specimen was collected at nearby Mount Kariong Trig, it was not seen on Mount Kariong during this survey. Present also in the Blue Mountains and in a few other areas of the New South Wales Central Coast.

Eucalyptus luehmanniana (Myrtaceae), a mallee occurring in low woodland to low open-woodland (Community 6) between rock outcrops on sandstone slopes. This species is restricted to the New South Wales Central Coast, from Helensburgh to Gosford. Within the Park it has been found on the southern side of Mount Kariong and near Green Point Creek in the Old Warrah Sanctuary.

Leucopogon amplexicaulis (Epacridaceae), a straggling shrub found in sheltered, moist places near rock outcrops, usually in relatively undisturbed areas with low fire frequency. Recorded only from the South Coast and Central Coast of New South Wales.

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* As defined by Hartley & Leigh (1979) " 'endangered' = species at serious risk of disappearing from the wild state within one to two decades if present land use and other casual factors continue to operate; 'vulnerable '= species not presently endangered but at risk over a long period if land-use patterns are introduced which would be deleterious to the species."

Leucopogon margarodes (Epacridaceae), a shrub found in the moist, dense understorey of the open-forest on Hawkesbury Sandstone, in areas not burnt for 8–10 years. Known from southern Queensland and the North Coast of New South Wales as far south as Wondabyne.

Boronia fraseri (Rutaceae), a shrub found in the moist understorey of open-forest (Community 2B). Recorded only from the Central Coast of New South Wales (Menangle to Woy Woy) and the lower eastern slopes of the Blue Mountains.

Allania endlicheri (Liliaceae), a species showing a disjunct distribution pattern, found on wet rocks in moist gullies with low open-forest in the Piles Creek area of Brisbane Water National Park. Also on Mount Coricudgy and in the Blue Mountains.

Two ferns are of restricted distribution and considered to be vulnerable also. They are:

Blechnum ambiguum (Blechnaceae), occurring on wet rocks in caves, under rock ledges, in wet crevices or near waterfalls, in open-forest with a moist understorey (Community 2B). This species is found on the Blue Mountains, South Coast, and Central Coast of New South Wales. It has been recorded at Wondabyne and Girrakool (R. G. Coveny 1969–78) and in the Old Warrah Sanctuary (D. V. Cameron, 1974) although the most northerly herbarium collection was from Narrabeen, south of Brisbane Water National Park.

Lindsaea dimorpha (Lindsaeaceae), a tiny fern found twice in the northwestern part of the Park on moist, shallow sandy soil with a high organic content, within scrub (Community 8) and open-woodland with a dense shrub understorey (Community 6). Known from Queensland and in New South Wales mainly from near Nowra on the South Coast. There are also records of it occurring near Penrith and in Dharug National Park; its discovery in Brisbane Water National Park extends the known range.

Taxa showing very restricted distribution patterns include:

Darwinia glaucophylla (Myrtaceae), an endemic and highly distinctive species found on rock outcrops with pockets of low scrub (Community 9) and in closed to open-scrub (Community 8) where this occurs close to rock outcrops. It is known only from the Calga-Piles Creek-Kariong area. The only area where its habitat is protected is in the north-western section of Brisbane Water National Park, on rock platforms to the north and west of Mt Kariong, and rock outcrops near Girrakool.

Darwinia procera (Myrtaceae), a restricted species recorded on a rocky ridge in low open-woodland (Community 6) with dry scrubby understorey. Known from a number of localities on the Central Coast of New South Wales, it has been collected near Piles Creek, the most northerly limit of its known distribution.

Grevillea shiressii (Proteaceae), a tall shrub growing on alluvial soil in open-forest with a moist understorey (Community 2B). This species is known from 2 localities only. Neither is within the present Park boundaries. Hartley & Leigh (1979) list it as a restricted endemic with a limited population range which is endangered.

Grevillea sp. aff. *capitellata* (Proteaceae), an undescribed species found in low open-forest (Community 4) with a dense shrubby understorey and in scrub (Community 8). It is only known to occur in the Peats Ridge, Mount White, Calga and Mangrove Mountain area to the west of Mooney Mooney Creek. Within the Park it occurs on the dry sandstone ridges west of Mooney Mooney Creek.

Grevillea sp. nov. (Proteaceae), an undescribed, small-leaved species which appears to have a very restricted distribution. It is found occasionally in the low open-forest and low woodland to low open-woodland communities on sandstone ridges on the scarp in the Somersby to Narara area.

Styphelia laeta var. *latifolia* (Epacridaceae), found in the dense shrubby understorey of open-forest to low open-forest on Hawkesbury sandstone slopes (Community 4), in low open-forest of plateau tops with earthy soils (Community 4P) and in low woodland (Community 6). This variety is known only from the Gosford-Ourimbah-Kulnura-Peats Ridge area. Another variety of this species, *S. laeta* var. *laeta*, was found in the south of the Park. There appears to be a possibility of hybridization between this variety and *Styphelia longifolia* (J. M. Powell, National Herbarium, pers. comm.); this requires further investigation.

Patches of hybrids between *Conospermum taxifolium* and *C. longifolium* subsp. *longifolium* (Proteaceae) occur in the Park, between Mooney Mooney Creek and Girrakool. (D. McGillivray, National Herbarium, pers. comm.).

If populations of these restricted species are disturbed or damaged in the Park and its environs then recovery is unlikely as local propagule sources are rare or unavailable.

Plant Community Distributions

The distribution of the plant communities primarily reflects geological, soil, drainage and aspect differences. Several of the communities are uncommon in the area and/or have very restricted distributions, and some are endangered by man's activities.

The southern parts of the study area south of the Pacific Highway, are dominated by ridges and slopes of Hawkesbury Sandstone; open-forest and closed to open-scrub (Communities 4 and 8) dominate these areas, often forming a continuum. There are occasional rock outcrops with pockets of heath (Community 9), each of very limited extent, and some *Gahnia*-dominated sedgelands (Community 12) in 'swampy' valleys lining the watercourses. Both communities are uncommon in this area. The open-forest (Community 4S) is an unusual feature of the south of the Park. This community is botanically and ecologically interesting; it is floristically quite distinctive and appears to be restricted to remnant shale outcrops in Hawkesbury Sandstone.

A different group of plant communities predominate in the north of the study area. On the ridgetops and plateaux are deep yellow earth soils with open-forest (Community 4P). Since this soil is favoured by orchardists only small pockets of vegetation remain. An isolated patch of this community occurs in the south of the Park along the Patonga road near Warrah Trig. Sedgelands (Community 12) seem to be far more extensive in the north and are particularly common on the scarp of the Hunter Range east of Somersby. They rely heavily on natural drainage patterns and any changes to these will greatly affect this community. Many sedgelands occur close to farmed areas and are not within the Park.

The vegetation of valleys which cut deep into Narrabeen Group strata is better developed in the northern part of the area. These protected moist valleys support closed-forest (Community 1) and open-forest with a moist understorey (Community 2B). The main valleys are those of Mooney Mooney Creek and Narara Creek (in Strickland State Forest). The closed-forest in Strickland State Forest is particularly rich in rainforest species. Drainage from farms into Communities 1 and 2B will bring increased nutrients (from fertilizers and sediment), possibly some pesticides and herbicides, and seeds. Weed problems are likely to increase, particularly along creek lines, e.g. into upper Mooney Mooney Creek.

The coastal and estuarine communities (3, 5, 7, 10 and 11) are not extensive and have been greatly disturbed by urban development. Very few relatively undisturbed areas remain, and few of these are within the Park. The most extensive areas of mangroves (Community 7) left in the study area occur along Patonga and Mooney Mooney Creek. In Native Dog Bay on Mooney Mooney Creek, mangroves have been affected by deposits of sediments from erosion (following highway construction) upstream. Mangroves play an essential role in estuarine ecosystems and are particularly important to both oyster and fish populations which are harvested commercially. Their conservation and protection is important. Reedland/rushland with *Casuarina glauca* (Community 11) occurs only in small isolated areas along Mooney Mooney, Mullet and Patonga Creeks. The only saltmarsh located during the survey consisted of two areas on Patonga Creek; the larger of these was being destroyed by trail bikes. None of the estuarine-associated plant communities are at present protected by conservation legislation.

Fire

During the preparation of the vegetation map some relationships were found between fire history and structural formation, species composition and the distribution of some rare species. For example, closed to open-scrub (Community 8) with regular burning appears to become dominated by the seed-regenerating species *Banksia ericifolia* and *Hakea teretifolia*. These species are killed by fire and regenerate from seed. However *Banksia ericifolia*, in particular, takes five years to flower and plants do not carry heavy seed loads until they are 8 to 10 years of age (Recher 1980). Maintenance of this community therefore requires a period between burning of at least 8 to 10 years but less than about 25 years.

The minimum period between fires is probably important for many species. A number of the rare species, for example, *Darwinia procera*, *Leucopogon amplexicaulis*, *L. margarodes* and *Boronia anemonifolia*, were found in areas which had not been burnt for at least eight years. There is much debate on the proper use of fire as a management tool in natural areas. Only when sufficient biological information on communities and species is available can scientifically based conclusions be drawn.

For many other aspects of management, further information is required on the biology and life histories of individual species and the inter-relationships between them. Monitoring of change over time within and between plant communities could be carried out in a number of ways, including permanent quadrats set out on a grid or random basis, colour oblique or low level aerial photography regularly taken over selected sites, or a combination of both quadrats and photography.

ACKNOWLEDGMENTS

We wish to thank R. G. Coveny and the botanists of the National Herbarium of New South Wales for help with identification of plant specimens; B. Vile and staff of the National Parks and Wildlife Service for information on aspects of Brisbane Water National Park; J. M. Powell, D. H. Benson and members of the technical staff of the National Herbarium, particularly E. Bie, for assistance with the maps, diagrams and tables.

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TABLE 1

Species list for communities identified in Brisbane Water National Park and environs

The species list is compiled from fieldwork records and from existing lists for areas within the Park. These include lists by R. G. Coveny (1969–1978) for the Wondabyne (RGC-W) and Girrakool (RGC-G) areas and by D. V. Cameron (1974) for the Old Warrah Sanctuary (DVC).

The list is arranged alphabetically within families and genera within the Pteridophytes, Gymnosperms, Angiosperms—Dicotyledons and Angiosperms—Monocotyledons. Exotic species are marked with an asterisk (*). The communities within which individual species occurred are indicated by the community numbers (as used in the text). Species names are those currently recognized at the National Herbarium of New South Wales (Jacobs & Pickard, 1981).

Botanical name	Community	Other Collectors
PTERIDOPHYTES		
PSILOPSIDA		
PSILOTACEAE		
Psilotum nudum	4	
Tmesipteris truncata		RGC-W
LYCOPSIDA		
LYCOPODIACEAE		
Lycopodium cernuum		RGC-W
L. deuterodensum	4P	
L. laterale	12	
SELAGINELLACEAE		
Selaginella uliginosa	2B, 4, 12	
PTEROPSIDA		
ADIANTACEAE		
Adiantum aethiopicum	1, 4, 5	
A. formosum	1	
A. hispidulum		RGC-WG
A. silvaticum	1, 2B	
Cheilanthes distans		DVC, RGC-WG
C. sieberi	2A, 2B	
Pelaea falcata		DVC
ASPIDIACEAE		
Lastreopsis decomposita		RGC-WG
L. microsora		DVC, RGC-WG
ASPLENIACEAE		
Asplenium australasicum		RGC-WG
A. flabellifolium	1	
BLECHNACEAE		
Blechnum ambiguum		DVC, RGC-WG
B. camfieldii		RGC-WG
B. cartilagineum	1, 2B, 4	
B. nudum		DVC
B. wattsii		DVC
Doodia aspera	1, 2B, 4	
D. caudata var. *laminosa*		RGC-W
CYATHEACEAE		
Culcita dubia	1, 2B, 4, 5	
Cyathea australis	1	
C. cooperi		DVC, RGC-G
DAVALLIACEAE		
Davallia pyxidata	1	
**Nephrolepis cordifolia*		DVC
DENNSTAETIACEAE		
Histiopteris incisa		DVC
Hypolepis muelleri	1	
H. punctata		RGC-G
Pteridium esculentum	1, 2A, 2B, 4, 4P, 4S, 5, 6, 10, 11, 12	
GLEICHENIACEAE		
Gleichenia dicarpa	4	
G. microphylla	4, 12	
G. rupestris	4	
Sticherus flabellatus	4, 4P	

Botanical name	Community	Other Collectors
GRAMMITIDACEAE		
Grammitis billardieri	1	
HYMENOPHYLLACEAE		
Hymenophyllum cupressiforme	1	
LINDSAEACEAE		
Lindsaea dimorpha	4, 8	
L. linearis	4, 4P, 6	
L. microphylla	2A, 2B, 4S	
OSMUNDACEAE		
Todea barbara	1, 2B, 4	
POLYPODIACEAE		
Dictymia brownii	1	
Microsorium scandens		RGC-G
Platycerium bifurcatum	1	
Pyrrosia rupestris	4	
SCHIZEACEAE		
Schizaea dichotoma	1, 4, 4P	
S. rupestris		RGC-WG
GYMNOSPERMS		
CUPRESSACEAE		
Callitris muelleri	1, 2A, 4, 6, 10	
PODOCARPACEAE		
Podocarpus spinulosus	4, 5	
ZAMIACEAE		
Macrozamia communis	2A, 3, 4, 4S	
ANGIOSPERMS		
DICOTYLEDONS		
ACANTHACEAE		
Brunoniella ? pumillo	4	
Pseuderanthemum variabile	1, 2A, 2B, 4	
AIZOACEAE		
Carpobrotus glaucescens		DVC
APIACEAE		
Actinotus helianthi	4	
A. minor	4, 4P, 6, 8	
Apium prostratum	11	
Centella asiatica	10	
Daucus glochidiatus	2A, 2B	
Hydrocotyle acutiloba	1, 2A, 2B, 5	
H. laxiflora	4	
**H. bonariensis*	5	
Platysace ericoides ?		RGC-W?
P. lanceolata	1, 2A, 2B, 4, 5, 9	
P. linearifolia	2A, 2B, 4, 4P, 4S, 6, 8	
Xanthosia dissecta	4	
X. pilosa	2A, 4, 6	
X. tridentata	2A, 4, 4S, 6, 12	
APOCYNACEAE		
Parsonsia straminea		RGC-WG
ARALIACEAE		
Astrotricha crassifolia	4	
A. floccosa	1, 4	
Polyscias murrayi	1, 4	
ASCLEPIADACEAE		
**Gomphocarpus fruticosus*	2B	
Marsdenia suaveolens		RGC-WG
ASTERACEAE		
**Ageratina adenophora*	10, 11	
**Ambrosia tenuifolia*		RGC-W
**Aster subulatus*	1, 10	
Brachycome sp.	1	
Cassinia aculeata		DVC
C. denticulata		DVC

Botanical name	Community	Other Collectors
C. longifolia	11	
**Chrysanthemoides monilifera*	10	
**Cirsium vulgare*	11	
**Conyza albida*	4	
Cotula longipes	10 ,11	
Epaltes australis		RGC-W
**Facelis retusa*	4	
Gnaphalium sp.	2A	
Helichrysum diosmifolium	4P, 11	
H. elatum		RGC-WG
**Hypochoeris radicata*	1, 2A, 2B, 4, 10	
Lagenifera stipitata	4	
Olearia tomentosa	4	
Senecio hispidulus	2A, 4	
S. lautus	11	
S. minimus	11	
Sigesbeckia orientalis	1	
**Sonchus oleraceus*	10, 11	
**Tagetes minuta*		RGC-W
BAUERACEAE		
Bauera rubioides var. *rubioides*	4, 6, 12	
BIGNONIACEAE		
Pandorea pandorana	1, 2A, 2B, 5	
CAMPANULACEAE		
Wahlenbergia spp.	2A, 2B, 4, 11	
CAPRIFOLIACEAE		
**Lonicera japonica*	1	
CASSYTHACEAE		
Cassytha paniculata	1, 4, 10	
C. pubescens	4, 4P, 8	
CASUARINACEAE		
Casuarina distyla	4, 6, 8, 9	
C. glauca	10, 11	
C. littoralis	4	
C. torulosa	1, 2A, 2B, 3, 4	
CELASTRACEAE		
Elaeodendron australe	1	
Maytenus silvestris	1	
CHENOPODIACEAE		
Chenopodium glaucum		RGC-W
Sarcocornia quinqueflora	7, 10	
CHLOANTHACEAE		
Chloanthes stoechadis	4, 11	
CONVOLVULACEAE		
**Convolvulus arvensis*		DVC
Dichondra repens	2A, 4, 10	
CRASSULACEAE		
Crassula helmsii		DVC
C. sieberana	4	
CUNONIACEAE		
Callicoma serratifolia	1, 4, 4P	
Ceratopetalum apetalum	4	
C. gummiferum	2A, 4, 4S	
Schizomeria ovata	2A, 2B	
DILLENIACEAE		
Hibbertia aspera		RGC-W
H. bracteata	4, 4P, 8	
H. cistiflora	4, 6, 8	
H. dentata	1, 2B, 4	
H. empetrifolia	2A, 2B, 4, 4P, 6, 10	
H. fasciculata	4	
H. linearis	8	

Botanical name	Community	Other Collectors
H. obtusifolia	4, 4P, 6, 9	
H. stricta	8	
H. scandens	2B	
DROSERACEAE		
Drosera auriculata	2B, 4, 4P, 6, 8	
D. binata	12	
D. peltata	4, 6, 8	
D. pygmaea		DVC, RGC-WG
D. spathulata	4, 12	
ELAEOCARPACEAE		
Elaeocarpus reticulatus	1, 2B, 4	
EPACRIDACEAE		
Acrotriche divaricata		RGC-WG
Astroloma pinifolium	4	
Brachyloma daphnoides	4, 4S, 6	
Dracophyllum secundum	2A	
Epacris crassifolia		RGC-WG
E. longiflora	4, 6	
E. microphylla	4, 6, 8, 9	
E. obtusifolia	4, 6, 8, 12	
E. pulchella	4, 4P, 4S, 6, 8, 9, 10	
E. purpurascens var. *purpurascens*		DVC
Leucopogon amplexicaulis	4	
L. ericoides	4	
L. esquamatus	6, 8, 9	
L. margarodes	4	
L. microphyllus	6, 8, 9, 12	
L. parviflorus	10	
Melichrus procumbens	4	
Monotoca elliptica	3	
M. scoparia	2A, 4, 4P, 4S, 6	
Sprengelia incarnata	8, 12	
Styphelia laeta var. *laeta*	4, 4P	
S. laeta var. *latifolia*	4, 4P	
S. longifolia		DVC
S. tubiflora	4	
Trochocarpa laurina	1, 2B, 4	
Woollsia pungens	4, 6, 9	
ESCALLONIACEAE		
Abrophyllum ornans	1, 2A	
EUPHORBIACEAE		
Amperea xiphoclada	2B, 4	
Breynia oblongifolia	1, 2B	
Glochidion ferdinandi	2A, 2B, 4	
Micrantheum ericoides	4	
Monotaxis linifolia	12	
Phyllanthus gasstroemii	1, 2A, 2B	
P. thymoides	2A, 4, 4P, 4S, 6, 10	
Poranthera ericifolia	4	
P. microphylla	1, 2A, 2B, 10	
Pseudanthus pimeleoides		DVC
Ricinocarpos pinifolius	4, 6, 8	
EUPOMATIACEAE		
Eupomatia laurina	1	
FABACEAE		
Aotus ericoides	1	
Bossiaea ensata	6, 8	
B. heterophylla	4, 4P, 6	
B. obcordata	4, 4P, 6	
B. scolopendria	4, 4P, 6, 8	
B. stephensonii	4, 4S, 6	
Daviesia alata		DVC

Botanical name	Community	Other Collectors
D. ulicifolia	4S	
Desmodium rhytidophyllum		RGC-W
D. varians	2B, 4	
Dillwynia floribunda	2A, 4, 8, 9, 12	
D. retorta	4, 4P, 6	
D. sericea subsp. B	4	
Glycine clandestina	2A, 2B, 4	
Gompholobium glabratum	6	
G. grandiflorum	4, 4P, 4S, 6	
G. latifolium	2A, 2B, 4, 4P, 4S	
Hardenbergia violacea	2A, 4, 5	
Hovea linearis	2A, 6	
Indigofera australis	1, 2B	
Kennedia rubicunda	1, 2A, 2B, 10	
Mirbelia rubiifolia	6, 8	
Oxylobium ilicifolium	1, 2A, 2B, 4S	
Phyllota phylicoides	4, 4P, 6	
Platylobium formosum	2A, 4P, 4S, 5	
Pultenaea daphnoides	2A, 4, 4S, 5, 10	
P. elliptica	2A, 4, 4S, 6	
P. ferruginea var. *deanei*	2A, 4, 4S, 10	
P. flexilis	1, 2A, 2B, 4, 5	
P. paludosa	12	
P. rosmarinifolia	4, 4P, 4S, 6, 9	
Sphaerolobium vimineum	8	
Viminaria juncea	8	
GERANIACEAE		
Geranium solanderi	2B	
Pelargonium australe		DVC
P. inodorum	2A	
GOODENIACEAE		
Dampiera stricta	2A, 2B, 4, 4P, 6, 8, 12	
Goodenia bellidifolia	4, 4S, 8	
G. dimorpha var. *dimorpha*	4	
G. heterophylla	2A, 4, 6	
G. ovata	1, 10	
G. paniculata		DVC
Scaevola ramosissima	4, 4P	
Velleia lyrata		DVC
HALORAGACEAE		
Gonocarpus micranthus		RGC-W
G. salsoloides	8, 12	
G. tetragynus		DVC
G. teucrioides	2A, 4, 4P, 5, 6	
HYPERICACEAE		
Hypericum japonicum		RGC-W
LAMIACEAE		
Hemigenia purpurea	6, 9	
Plectranthus parviflorus	2B, 4	
Prostanthera linearis	4	
P. rhombea		RGC-W
Westringia fruticosa	10	
LAURACEAE		
Cryptocarya glaucescens	1	
Endiandra sieberi	1, 4	
LENTIBULARIACEAE		
Utricularia dichotoma		DVC, RGC-G
U. lateriflora		DVC
U. uliginosa	6, 8	

Botanical name	Community	Other Collectors
LOBELIACEAE		
Lobelia alata	10, 11	
L. dentata		DVC
L. gibbosa		RGC-W
Pratia purpurascens	2A, 2B, 4, 5	
LOGANIACEAE		
Logania albiflora	4	
Mitrasacme polymorpha	4, 4P, 6	
LORANTHACEAE		
Amyema miquelii	4, 6	
Muellerina celastroides		RGC-W
M. eucalyptoides		RGC-W
MALVACEAE		
Howittia trilocularis		DVC
**Sida rhombifolia*	1	
MELIACEAE		
Synoum glandulosum	1	
MENISPERMACEAE		
Sarcopetalum harveyanum	4	
Stephania japonica var. *discolor*	1, 10	
MIMOSACEAE		
Acacia elata	1, 2B, 4	
A. farnesiana		RGC-W
A. fimbriata		RGC-W
A. floribunda	1	
A. implexa	1, 2A, 2B, 4, 11	
A. irrorata	1	
A. linifolia	2A, 4, 4P, 4S	
A. longifolia	2A	
A. maidenii	4	
A. myrtifolia	4P, 4S	
A. oxycedrus	4, 6, 8, 9, 12	
A. parramattensis	5	
A. prominens	2B	
A. schinoides	2B	
A. suaveolens	4, 4P, 5, 6, 8, 12	
A. terminalis	2A, 4, 4P, 6	
A. ulicifolia	2A, 4, 4P, 4S, 6	
MONIMIACEAE		
Doryphora sassafras	1	
Palmeria scandens	1	
Wilkiea huegeliana	1	
MORACEAE		
Ficus coronata	1	
F. rubiginosa	4, 10	
F. superba var. *henneana*		DVC
MYOPORACEAE		
Myoporum acuminatum	7, 11	
M. insulare	10	
MYRSINACEAE		
Aegiceras corniculatum	7	
Rapanea howittiana	1	
R. variabilis	1, 2A, 2B, 4, 5	
MYRTACEAE		
Acmena smithii	1, 2B, 4, 5	
Angophora costata	1, 2A, 3, 4, 4P, 4S, 5, 6, 10	
A. floribunda	1, 2A, 2B, 3, 4, 10	
A. hispida	4, 5, 8, 9, 12	
Austromyrtus tenuifolia	4, 11	
Backhousia myrtifolia	1, 4,	
Baeckea brevifolia	9	
B. diosmifolia	6	
B. imbricata	4, 8, 10, 12	

Botanical name	Community	Other Collectors
B. linifolia	4, 9	
Callistemon citrinus	4, 12	
C. linearis	4, 9	
Calytrix tetragona	6, 8	
Darwinia fascicularis subsp. *fascicularis*	6, 8, 9, 12	
D. glaucophylla	8, 9	
D. procera	9	
Eucalyptus acmenoides	2B	
E. botryoides	3, 5	
E. capitellata	4, 4P, 6	
E. deanei	1, 2B	
E. eximia	4, 4P, 6, 9	
E. globoidea	4S	
E. gummifera	2A, 3, 4, 4P, 4S, 6	
E. haemastoma	4, 4P, 4S, 6, 8, 9	
E. luehmanniana	6	
E. maculata	3	
E. multicaulis	6	
E. oblonga	4, 4P, 4S, 6	
E. paniculata	2A, 3	
E. pellita	4	
E. piperita subsp. *piperita*	2A, 4, 4P	
E. punctata	4, 4P, 4S, 6	
E. resinifera	2A	
E. squamosa		DVC
E. sieberi	4, 4P	
E. umbra subsp. *umbra*	2A, 4, 4S, 5, 6, 8, 10	
Kunzea ambigua	8	
K. capitata	4, 6, 8, 9	
Leptospermum arachnoides	9	
L. attenuatum	2A, 4, 4P, 6, 8, 9	
L. flavescens	1, 2A, 2B, 4, 4P, 4S, 6, 8, 9	
L. juniperinum	6, 12	
L. laevigatum	10	
L. lanigerum	4	
L. parvifolium	9	
L. scoparium	4, 12	
L. squarrosum	4, 8	
Melaleuca deanei	6	
M. styphelioides	11	
Syncarpia glomulifera	1, 2A, 2B, 4, 4P, 4S, 6	
Syzygium coolminianum	1	
Tristania laurina	1, 2A, 4	
T. neriifolia	4	
OLACACEAE		
Olax stricta	9	
OLEACEAE		
**Ligustrum sinense*		RGC-G
Notelaea longifolia	1, 5	
N. venosa	1	
OXALIDACEAE		
Oxalis corniculata	4, 11	
PEPEROMIACEAE		
Peperomia tetraphylla	2B	
PHYTOLACCACEAE		
**Phytolacca octandra*	11	
PITTOSPORACEAE		
Billardiera scandens	2A, 2B, 4, 4P, 6	
Bursaria spinosa	1, 2A	
Citriobatus pauciflorus		RGC-W
Pittosporum undulatum	1, 2A, 10	
P. revolutum	1	

Botanical name	Community	Other Collectors
PLANTAGINACEAE		
Plantago debilis	4, 10	
**P. lanceolata*		RGC-W
POLYGALACEAE		
Comesperma ericinum	4	
C. sphaerocarpum		DVC, RGC-W
C. volubile	2B, 4	
POLYGONACEAE		
**Acetosa sagittata*	10	
**Acetosella vulgaris*		RGC-W
**Polygonum aviculare*		RGC-W
P. decipiens		RGC-W
Rumex brownii		RGC-W
PORTULACACEAE		
**Portulaca oleracea*		RGC-W
PRIMULACEAE		
Samolus repens	11	
PROTEACEAE		
Banksia aspleniifolia	4, 6, 8, 9, 12	
B. ericifolia	2A, 4P, 6, 8, 9, 12	
B. integrifolia	3, 5, 10	
B. robur	12	
B. serrata	2A, 4P, 6	
B. spinulosa	2A, 2B, 4, 4P, 4S, 6	
Conospermum longifolium subsp. *longifolium*	4, 4P, 6	
C. taxifolium (narrow-leaved form)	6, 8, 9	
C. tenuifolium		RGC-G
Grevillea buxifolia	2A, 4, 4P, 6	
G. sp. aff. *capitellata*	4, 8	
G. linearifolia	4	
G. sericea	4, 4P, 4S, 6, 8	
G. shiressii	2B	RGC-W
G. speciosa	6, 8, 9, 12	
Hakea dactyloides	2A, 4, 4P, 4S, 6, 8	
H. gibbosa	4, 4P, 6, 8, 10	
H. propinqua	4, 6, 8, 9	
H. salicifolia	2B, 4	
H. sericea	2A, 4, 4P, 4S	
H. teretifolia	4P, 6, 8, 9, 12	
Isopogon anemonifolius	4, 4P, 4S	
I. anethifolius	2A, 4, 6, 9	
Lambertia formosa	4, 4P, 4S, 6, 8, 9	
Lomatia myricoides	1, 2A, 4	
L. silaifolia	2A, 4, 4P, 4S, 6	
Persoonia lanceolata	2A, 4, 6, 8, 9	
P. levis	2A, 4, 4P, 4S, 6, 8	
P. linearis	1, 2A, 2B, 4, 4S	
P. pinifolia	2A, 4, 4P, 6, 8	
P. sp. aff. *pinifolia*	2A, 4, 4P, 6, 8	
Petrophile pulchella	4, 4P, 6, 8, 9	
Stenocarpus salignus	2B	RGC-WG
Symphionema paludosum	9	
Telopea speciosissima	4P	
Xylomelum pyriforme	4, 4P, 4S	
RANUNCULACEAE		
Clematis aristata	1, 2A, 2B, 5	
RHAMNACEAE		
Alphitonia excelsa		RGC-W
Cryptandra ericoides	8	
Pomaderris ferruginea		DVC, RGC-G
P. ligustrina		RGC-W
P. multiflora		RGC-WG
P. sieberana	2A, 4	

Botanical name	Community	Other Collectors
ROSACEAE		
Rubus hillii	1	
R. parvifolius	2B, 4	
RUBIACEAE		
Canthium coprosmoides		RGC-WG
Galium binifolium	2B, 4	
G. propinquum	4	
Morinda jasminoides	1	
Opercularia aspera	1, 4, 10, 11	
O. hispida ?		RGC-W
O. varia	4	
Pomax umbellata	1, 2A, 2B, 4	
RUTACEAE		
Asterolasia correifolia	1, 4	
Boronia anemonifolia	4	
B. fraseri	1, 4	
B. ledifolia	4, 4P, 6	
B. parviflora	12	
B. pinnata	4, 4P, 4S, 6, 8	
B. polygalifolia		DVC
B. serrulata	6, 9	
Correa lawrenciana var. *macrocalyx*		DVC
C. reflexa var. *reflexa*	1, 4, 4S, 10	
Crowea saligna	4	
Eriostemon australasius	4, 6, 9	
E. buxifolius	4, 4P, 6	
Phebalium dentatum	4	
P. squamulosum subsp. *argenteum*	2B	
P. squamulosum subsp. *squamulosum*	6, 9	
Philotheca salsolifolia	6	
Zieria laevigata	4	
Z. pilosa	4	
Z. smithii	1	
SANTALACEAE		
Exocarpos cupressiformis	4	
Leptomeria acida	2A, 4, 4P	
SAPINDACEAE		
Alectryon subcinereus	1	
Dodonaea boroniifolia		DVC
D. camfieldii		RGC-WG
D. pinnata	4	
D. triquetra	2A, 2B, 4, 4P	
Guioa semiglauca	1	
SCROPHULARIACEAE		
Veronica plebeia	1	
SOLANACEAE		
Duboisia myoporoides	1	
Solanum campanulatum		DVC
**S. mauritianum*	1	
S. nodiflorum subsp. *nutans*		RGC-W
S. prinophyllum	1, 2A, 4, 11	
S. pungetium		DVC
STACKHOUSIACEAE		
Stackhousia monogyna	2A, 2B	
S. nuda		DVC, RGC-W
S. viminea	4	
STERCULIACEAE		
Lasiopetalum ferrugineum var. *ferrugineum*	2A, 4, 4S, 5	
L. macrophyllum	1, 5, 10	
STYLIDIACEAE		
Stylidium lineare	6	
S. productum	2A, 4, 6, 8	

Botanical name	Community	Other Collectors
SYMPLOCACEAE		
Symplocos thwaitesii	1	
THYMELAEACEAE		
Pimelea glauca	8, 12	
P. latifolia subsp. *C.*		RGC-W
P. linifolia	4, 4P, 4S, 6, 8	
Wikstroemia indica	10	
TREMANDRACEAE		
Tetratheca ericifolia	4, 6, 10	
T. shiressii	4, 8	
T. thymifolia	2A, 4, 4P, 6, 8	
ULMACEAE		
Trema aspera		RGC-WG
VERBENACEAE		
Avicennia marina var. *australasica*	7	
Clerodendrum tomentosum	1	
**Lantana camara*	1, 2A, 5, 10	
**Verbena bonariensis*		RGC-W
**V. rigida*		RGC-W
VIOLACEAE		
Hybanthus monopetalus		DVC, RGC-WG
Viola hederacea	1, 2B, 11	
VITACEAE		
Cayratia clematidea		RGC-WG
Cissus antarctica	1, 2B	
C. hypoglauca	1, 2B, 4, 5	
WINTERACEAE		
Tasmannia insipida	1	
ZYGOPHYLLACEAE		
**Tribulus terrestris*		RGC-W
MONOCOTYLEDONS		
AGAVACEAE		
Doryanthes excelsa	4, 4P	
ARACEAE		
Gymnostachys anceps	1, 2A, 4	
ARECACEAE		
Livistona australis	1, 2A, 3, 5	
CYPERACEAE		
Baumea acuta	4, 8	
B. juncea	11	
B. rubiginosa		DVC, RGC-W
B. sp. nov.		RGC-W
Carex appressa	11	
Caustis flexuosa	4, 4P, 6	
C. pentandra	9	
Chorizandra cymbaria	8, 12	
C. sphaerocephala	12	
Cladium procerum		RGC-W
Cyathochaeta diandra	4, 4P, 4S, 6, 8	
Cyperus brevifolius		RGC-W
C. laevis		RGC-W
C. polystachyos	10, 11	
Eleocharis sphacelata		RGC-W
Gahnia aspera	10	
G. clarkei	1, 4, 11, 12	
G. erythrocarpa		DVC, RGC-WG
G. melanocarpa	10	
G. radula	4S	
G. sieberana	2B	
Gymnoschoenus sphaerocephalus	12	
Lepidosperma elatius		RGC-W
L. filiforme		DVC

Botanical name	Community	Other Collectors
L. flexuosum	6, 8, 9, 12	
L. laterale	1, 2A, 4, 4P, 5, 6, 9	
L. limicola	6, 9, 12	
L. neesii		RGC-W
L. squamatum		RGC-W
L. urophorum	4, 6	
L. viscidum		RGC-W
Ptilanthelium deustum	4, 8, 12	
Schoenus brevifolius	6, 8, 12	
S. ericetorum	4, 4P, 6	
S. imberbis	4, 6	
S. melanostachys	2A, 4, 4P, 6, 8	
S. pachylepis		RGC-WG
S. paludosus	4, 12	
S. turbinatus	6	
S. villosus		RGC-G
Scirpus inundatus		RGC-W
S. nodosus	10	
S. validus		RGC-W
Tetraria capillaris	6, 8	
Tricostularia pauciflora	4, 6	
DIOSCOREACEAE		
Dioscorea transversa	1, 4	
HAEMODORACEAE		
Haemodorum corymbosum	4, 8, 12	
H. planifolium	4, 4P	
IRIDACEAE		
Libertia paniculata	4	
Patersonia fragilis	4	
P. glabrata	1, 2A, 4, 4P, 4S	
P. longifolia		DVC
P. sericea	2A, 4, 4P, 6, 8	
JUNCACEAE		
**Juncus articulatus*		RGC-W
J. kraussii	10, 11	
J. planifolius	4	
J. prismatocarpus		RGC-W
J. usitatus	11	
J. sp. 'x'	11	
Luzula meridionalis		DVC
JUNCAGINACEAE		
Triglochin procera		RGC-W
T. striata	10	
LILIACEAE		
Allania endlicheri		RGC-G
Arthropodium minus		RGC-W
Blandfordia sp.	12	
Burchardia umbellata	6	
Caesia vittata		DVC
Dianella caerulea	1, 2A, 2B, 4, 4P, 5, 6, 11	
D. laevis		RGC-W
D. revoluta	4, 4P, 4S, 6	
D. sp. aff. *revoluta*	2A	
Laxmannia gracilis	6	
Schelhammera undulata	1, 2B, 4	
Sowerbaea juncea	8	
Stypandra umbellata	4, 6	
Thysanotus juncifolius		RGC-W
T. tuberosus		DVC
Tricoryne elatior		DVC

Botanical name	Community	Other Collectors
ORCHIDACEAE		
Acianthus caudatus		RGC-W
A. fornicatus		RGC-W
A. reniformis		RGC-W
A. sp.	2A, 4, 4P	
Bulbophyllum crassifolium	1	
B. exiguum	4	
Caladenia alba		DVC
C. carnea	1, 4	
Caleana major	2B	
Calochilus campestris		DVC
C. paludosus		DVC
Chiloglottis sp.	4	
Corybas sp.	1, 2B, 4	
Cryptostylis erecta	2B, 4, 8	
Cymbidium suave	1, 2A, 2B	
Dendrobium aemulum		RGC-W
D. linguiforme	4	
D. speciosum	4, 9	
Dipodium punctatum		RGC-W
Diuris aurea		DVC
Eriochilus cucullatus	12	
Gastrodia sesamoides		DVC
Glossodia major	4	
G. minor	4, 4P, 6	
Liparis reflexa	1, 4	
Lyperanthus nigricans		RGC-W
L. suaveolens		RGC-W
Microtis unifolia		DVC
Plectorrhiza tridentata	1	
Prasophyllum aureoviride		RGC-W
P. elatum		DVC
P. fimbriatum		RGC-W
P. morrisii		DVC
Pterostylis curta	1	
P. grandiflora ?		RGC-G ?
P. longifolia	1, 2B, 4, 6	
P. nutans	2B	
P. pedunculata		RGC-W
Rimacola elliptica		RGC-WG
Spiranthes sinensis		DVC
Thelymitra ixioides	4, 6	
PHILESIACEAE		
Eustrephus latifolius	1, 2A, 2B, 4, 5	
Geitonoplesium cymosum	1, 2A	
PHILYDRACEAE		
Philydrum lanuginosum		RGC-W
POACEAE		
Agrastis avenacea	11	
**Andropogon virginicus*	1, 2A	
Anisopogon avenaceus	2A, 4, 4P, 4S, 8	
Aristida benthamii		RGC-W
A. vagans		RGC-WG
A. warburgii		RGC-W
**Axonopus affinis*		RGC-G
**Briza maxima*	10	
**B. minor*	11	
**Chloris gayana*		RGC-W
Cymbopogon refractus	2A, 4	
Cynodon dactylon	11	
Dichelachne micrantha	2B	
D. rara	2B	
Digitaria parviflora	2A	

Botanical name	Community	Other Collectors
D. sp.		RGC-W
**Echinochloa crus-galli*		RGC-W
Echinopogon caespitosus	1, 11	
**Eleusine indica*		RGC-W
Entolasia marginata	11	
E. stricta	1, 2A, 2B, 4, 4P, 4S, 6, 8	
Eragrostis brownii	4, 11	
Hemarthria uncinata	1, 4, 11	
Imperata cylindrica var. *major*	1, 2A, 4, 4S, 5, 6, 10	
Microlaena stipoides		RGC-W
Oplismenus aemulus		RGC-W
O. imbecillis	2A, 2B, 4	
Panicum simile		RGC-WG
Paspalidium radiatum	7, 11	RGC-W
Phragmites australis	10, 11	
Poa affinis	1, 4S	
**Setaria geniculata* var. *pauciseta*		RGC-W
Stipa pubescens	4	
Tetrarrhena juncea	4, 4P	
Themeda australis	1, 2A, 2B, 4, 4P, 4S, 5, 10	
RESTIONACEAE		
Empodisma minus	4, 6, 8, 12	
Hypolaena fastigiata	11	
Leptocarpus tenax	2B, 6, 9, 12	
Lepyrodia scariosa	4, 4P, 6, 8, 9, 12	
Restio complanatus	8, 12	
R. dimorphus	6, 8, 9	
R. fastigiatus	6, 8, 9, 12	
R. gracilis	8	
R. tetraphyllus subsp. *meiostachyus*		RGC-G
SMILACEAE		
Smilax australis	1, 2B, 4, 5	
S. glyciphylla	1, 2A, 4, 4P	
XANTHORRHOEACEAE		
Lomandra brevis		RGC-G
L. confertifolia subsp. *rubiginosa*	2A, 6	
L. cylindrica		RGC-WG
L. filiformis subsp. *coriacea*	4, 4P	
L. filiformis subsp. *filiformis*	1, 4, 4P, 6, 8	
L. glauca subsp. *glauca*	4, 4P, 6, 8	
L. longifolia	1, 2A, 2B, 3, 4, 4P, 4S, 5, 11	
L. multiflora	2A	
L. obliqua	2A, 4, 4S, 6, 8	
Xanthorrhoea arborea	2A, 4	
X. macronema		DVC
X. resinosa	6, 8, 12	
XYRIDACEAE		
Xyris gracilis subsp. *gracilis*	4, 6	
X. gracilis subsp. *laxa*	4P	
X. operculata	12	

VEGETATION OF SPECTACLE ISLAND, HAWKESBURY RIVER, NEW SOUTH WALES

JOAN B. WEBB

(Accepted for publication 9.12.1980)

ABSTRACT

Webb, Joan B. (*Kuring-gai College of Advanced Education, Lindfield, New South Wales, Australia* 2070) 1981. *Vegetation of Spectacle Island, Hawkesbury River, New South Wales. Cunninghamia* 1(1): 115–119. The vegetation of Spectacle Island is mapped and the species present are recorded.

INTRODUCTION

Spectacle Island (Lat. 33° 32′ S, Long. 151° 12′ E) is a small Hawkesbury Sandstone island in the Hawkesbury River, near its junction with Mooney Mooney Creek. It is about 1 200 m long and 600 m at its widest point, up to 123 m high, and has generally similar vegetation to that of the nearby Brisbane Water National Park (Benson & Fallding, this issue). It is a Nature Reserve administered by the New South Wales National Parks and Wildlife Service.

VEGETATION

The vegetation varies with aspect and topography, and may be mapped using nine distinct units (Figure 1). The species recorded are listed in Table 1.

1. North-facing, gentle slope, dominated by *Angophora floribunda* and grasses.
2. Mudflats, with the mangrove, *Avicennia marina* var. *australasica.*
3. Typical gully flora, land rising sharply from the river; *Angophora floribunda*, *Elaeocarpus reticulatus*, *Notelaea longifolia*, *Solanum* sp. and *Casuarina glauca.*
4. Steeply rising land dominated by *Eucalyptus gummifera*, *Angophora costata*, *Casuarina littoralis*, a number of *Lomandra* species and grasses. In area (e) a number of exotics are present, not abundant, but consistent with other evidence of European occupation such as concrete slabs and a constructed stone wall. Similar exotics (mainly succulents) are found near the eastern beachfront where two fishermen's huts are still *in situ.*
5. Southern facing aspect, steep slope leading to vertical scarp; area dominated by *Acacia elata*, *Xanthorrhoea* sp., *Pteridium esculentum*, *Casuarina glauca* on lower slopes and *Casuarina torulosa* and *Casuarina littoralis* higher up. The vegetation here is denser than on other parts of the island.
6. Relatively flat area of land, clay soil, only area of *Eucalyptus punctata* on the island.
7. Mahoganies, *E. umbra* subsp. *umbra* and *E. resinifera*, on the top and edges of the cliffs.
8. Flat top of the island, open woodland with only *Imperata cylindrica.* No understorey of *Xanthorrhoea* or other shrubs conspicuous on the rest of the island. Trees here are *Eucalyptus gummifera* and *Angophora costata.* Scattered shrubs of *Banksia marginata*, *Xylomelum pyriforme*, *Gompholobium latifolium*, *Kunzea ambigua* and *Xanthorrhoea* sp. occur around the margins of this highest area.
9. Gully flora close under the cliffs.

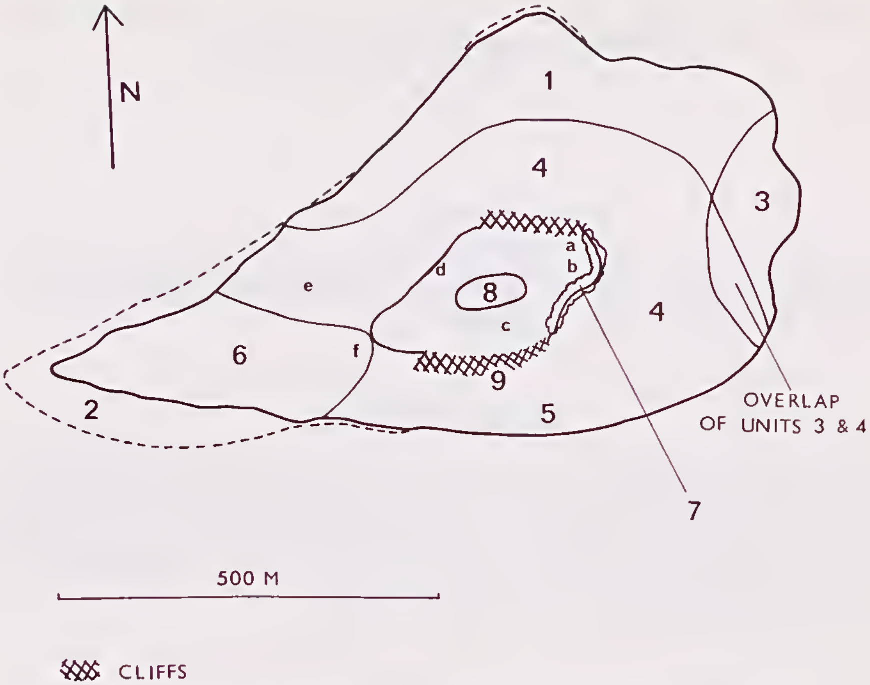

Figure 1. Sketch map of Spectacle Island showing vegetation units.

TABLE 1

Plant species recorded on Spectacle Island

Total number of recorded species = 128.

R = rare, i.e. not sighted more than once or twice.

a, b, c, d, etc. = positions on Figure 1.

Numbers 1–9 = vegetation units on Figure 1.

* = exotic species.

PTERIDOPHYTES

- Adiantaceae
    - *Adiantum aethiopicum*
    - *A. hispidulum*
    - *Pellaea falcata*
- Aspleniaceae
    - *Asplenium flabellifolium*
- Blechnaceae
    - *Blechnum ambiguum*
    - *B. cartilagineum*
- Cyatheaceae
    - *Cyathea* sp.
- Davalliaceae
    - *Davallia pyxidata*
- Dennstaedtiaceae
    - *Histiopteris incisa*
    - *Pteridium esculentum*
- Gleicheniaceae
    - *Sticherus* sp.
- Lindsaeaceae
    - *Lindsaea microphylla*
- Osmundaceae
    - *Todea barbara*
- Psilotaceae
    - *Psilotum nudum*

ANGIOSPERMS

DICOTYLEDONS

Acanthaceae	
Brunoniella australis	
Pseuderanthemum variabile	
Apiaceae	
Actinotus helianthi	
Platysace lanceolata	(R–5)
P. linearifolia	(R–f)
Xanthosia pilosa	
Araliaceae	
Astrotricha floccosa	
Asteraceae	
**Ageratina adenophora*	
Brachycome prob. *angustifolia*	
Helichrysum diosmifolium	(R–5)
Bignoniaceae	
Pandorea pandorana	(R–5)
Campanulaceae	
Wahlenbergia gracilis	
Cassythaceae	
Cassytha sp.	
Casuarinaceae	
Casuarina glauca	
C. littoralis	
C. torulosa	
Cunoniaceae	
Ceratopetalum apetalum	
C. gummiferum	
Droseraceae	
Drosera auriculata	
Dilleniaceae	
Hibbertia obtusifolia	
Elaeocarpaceae	
Elaeocarpus reticulatus	
Epacridaceae	
Dracophyllum secundum	
Epacris longiflora	(R–f)
E. pulchella	(R–f)
Euphorbiaceae	
Poranthera microphylla	
Fabaceae	
Dillwynia floribunda	(R–f)
Glycine clandestina	
Gompholobium latifolium	(b)
Hardenbergia violacea	
Hovea linearis	
Kennedia rubicunda	
Mirbelia rubiifolia	
Pultenaea flexilis	
P. retusa	
Goodeniaceae	
Goodenia heterophylla	
G. rotundifolia	
Scaevola ramosissima	(R–9)
Hypericaceae	
Hypericum japonicum	
Lamiaceae	
Plectranthus graveolens	
P. parviflorus	(R–5)
Lobeliaceae	
Pratia purpurascens	
Loganiaceae	
Logania albiflora	(R–9)
Meliaceae	
Synoum glandulosum	(R–9)

Menispermaceae	
Sarcopetalum harveyanum	
Mimosaceae	
Acacia elata	
A. longifolia var. *longifolia*	
A. maidenii	(R–9)
A. oxycedrus	(R–d)
A. suaveolens	(R–f)
Moraceae	
Ficus rubiginosa	
Myrtaceae	
Acmena smithii	
Angophora costata	
A. floribunda	
Backhousia myrtifolia	(R–9)
Callistemon linearifolius	(R–f)
Eucalyptus gummifera	
E. piperita subsp. *piperita*	
E. punctata	
E. resinifera	
E. umbra subsp. *umbra*	
Kunzea ambigua	
Leptospermum attenuatum	
Tristania laurina	(5,9)
Oleaceae	
Notelaea longifolia	
Pittosporaceae	
Bursaria spinosa	
Proteaceae	
Banksia integrifolia	
B. marginata	
B. serrata	
B. spinulosa	(R)
Grevillea sericea	(R–1 bush at a)
Hakea dactyloides	(R–e)
Persoonia levis	
P. linearis	
Xylomelum pyriforme	(3 trees at c)
Rhamnaceae	
Pomaderris multiflora	(R–f)
Rubiaceae	
Morinda jasminoides	(R–9)
Rutaceae	
Correa reflexa	
Phebalium sp.	
Santalaceae	
Exocarpos cupressiformis	
Solanaceae	
Solanum sp.	
Sterculiaceae	
Lasiopetalum ferrugineum var. *ferrugineum*	
L. macrophyllum	
Stylidiaceae	
Stylidium sp.	
Verbenaceae	
Avicennia marina	
Clerodendrum tomentosum	(R–9)
**Lantana camara*	(4 plants on northern side)
Violaceae	
Hybanthus monopetalus	
Vitaceae	
Cayratia clematidea	
Cissus hypoglauca	(R–9)

MONOCOTYLEDONS

Cyperaceae
- *Baumea juncea*
- *Caustis flexuosa*
- *Gahnia* sp.
- *Lepidosperma laterale*
- *Schoenus imberbis*

Iridaceae
- *Patersonia glabrata*

Liliaceae
- *Caesia vittata*
- *Dianella revoluta*
- *Thysanotus tuberosus*

Orchidaceae
- *Caladenia carnea*
- *Dendrobium linguiforme*
- *Pterostylis nutans*
- *Thelymitra ixioides*

Poaceae
- *Aristida vagans*
- *Cymbopogon refractus*
- *Dichelachne micrantha*
- *Eragrostis philippica*
- *Imperata cylindrica*
- *Sporobolus virginicus*
- **Stenotaphrum secundatum*
- *Stipa* sp.

Xanthorrhoeaceae
- *Lomandra confertifolia* subsp. *rubiginosa*
- *L. glauca*
- *L. gracilis*
- *L. longifolia* subsp. *longifolia*
- *L. obliqua*
- *Xanthorrhoea* sp.

Cunninghamia 1 (1): 121–123 (1981)

VEGETATION OF LION ISLAND, BROKEN BAY, NEW SOUTH WALES

D. H. Benson

(Accepted for publication 20.10.1980)

ABSTRACT

Benson, D. H. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia 2000) 1981. *Vegetation of Lion Island, Broken Bay, New South Wales. Cunninghamia* 1 (1): 121–123. A brief description of the vegetation of Lion Island is given, compiled from information collected in 1973 and 1974, and the species present recorded.

INTRODUCTION

Lion Island, (Lat. 33° 33′ S, Long. 151° 19′ E) situated at the entrance to Broken Bay, is a Nature Reserve administered by the New South Wales National Parks and Wildlife Service. The island is 560 m long and 280 m wide. It is highest at the eastern end (93 m a.s.l.) and descends to a saddle with a small rise (30 m a.s.l.) at the western end. There are cliffs on the eastern and southern sides. Geologically Lion Island is similar to the nearby Brisbane Water National Park. It is composed of a Hawkesbury Sandstone capping on the eastern end, with strata of the underlying Narrabeen Group exposed elsewhere.

VEGETATION

The major vegetation is low woodland dominated mainly by *Angophora costata*, but with *Eucalyptus botryoides* as co-dominant on the eastern end of the island. Scattered tall shrubs of species such as *Banksia serrata* and *Exocarpos cupressiformis* are generally present, and a low shrub layer up to 2 m high is continuous over most of the island. *Xanthorrhoea arborea* and *Lomandra longifolia* are conspicuous in this layer with shrubs such as *Platysace lanceolata*, *Hakea sericea*, *Dodonaea triquetra* and *Acacia ulicifolia*. The litter layer is very thick, commonly up to 10 cm deep and few herbs were recorded. There are scattered areas of bare rock. In 1973 the vegetation did not appear to have been burnt for many years.

At the western end of the island in a better protected saddle is low open-forest of *Banksia integrifolia* and *Casuarina littoralis* with a ground layer of *Adiantum aethiopicum*, *Lomandra longifolia* and *Commelina cyanea*. On more exposed sites this grades into scrub with *Leptospermum laevigatum* and *Banksia integrifolia*. *Lantana camara*, an exotic shrub species, is common in these situations.

On scree slopes at the eastern end of the island and exposed to the ocean, is herbland with *Commelina cyanea*, *Lobelia alata* and *Dichondra repens*. Shrubs of *Westringia fruticosa* are found in cracks between large sandstone boulders and higher up on cracks and ledges on the cliff faces. In one place the scrambling climber *Flagellaria indica* forms a dense low scrub.

TABLE 1

Species recorded on Lion Island 1973–74

The list is not exhaustive.

* = exotic species

PTERIDOPHYTES
Adiantaceae
    Adiantum aethiopicum
    Cheilanthes tenuifolia
Aspleniaceae
    Asplenium obtusatum var. *difforme*
Dennstaedtiaceae
    Histiopteris incisa
    Pteridium esculentum
Psilotaceae
    Psilotum nudum

GYMNOSPERMS

Podocarpaceae
Podocarpus spinulosus

Zamiaceae
Macrozamia communis

ANGIOSPERMS

DICOTYLEDONS

Acanthaceae
Pseuderanthemum variabile

Aizoaceae
Carpobrotus glaucescens

Apiaceae
Actinotus helianthi
Apium prostratum
Platysace lanceolata
P. linearifolia

Asteraceae
**Conyza canadensis*
**Gnaphalium luteo-album*
**Hypochoeris radicata*
Senecio minimus

Casuarinaceae
Casuarina distyla
C. littoralis

Chenopodiaceae
Chenopodium polygonoides
Rhagodia baccata

Convolvulaceae
Dichondra repens

Crassulaceae
Crassula sieberana

Dilleniaceae
Hibbertia obtusifolia

Fabaceae
Dillwynia retorta
Hardenbergia violacea
Kennedia rubicunda
Pultenaea deanei

Goodeniaceae
Goodenia belledifolia
G. ovata
Scaevola ramosissima

Lamiaceae
Westringia fruticosa

Lobeliaceae
Lobelia alata

Loranthaceae
Muellerina celastroides

Menispermaceae
Stephania japonica

Mimosaceae
Acacia longifolia
A. suaveolens
A. ulicifolia

Moraceae
Ficus rubiginosa

Myrtaceae
Acmena smithii
Angophora costata
Callistemon rigidus
Eucalyptus botryoides
E. paniculata
Leptospermum laevigatum

Myrsinaceae
- *Rapanea howittiana*
- *R. variabilis*

Oleaceae
- *Notelaea longifolia*

Pittosporaceae
- *Billardiera scandens*
- *Pittosporum undulatum*

Polygonaceae
- *Rumex brownii*

Portulacaceae
- *Calandrinia* sp.

Proteaceae
- *Banksia ericifolia*
- *B. integrifolia*
- *B. serrata*
- *Hakea dactyloides*
- *H. sericea*
- *Isopogon anethifolius*
- *Persoonia linearis*
- *Petrophile pulchella*

Rutaceae
- *Eriostemon australasius*
- *E. buxifolius*

Santalaceae
- *Exocarpos cupressiformis*

Sapindaceae
- *Dodonaea triquetra*

Solanaceae
- *Solanum nodiflorum*

Stylidiaceae
- *Stylidium productum*

Thymelaeaceae
- *Wikstroemia indica*

Verbenaceae
- **Lantana camara*

MONOCOTYLEDONS

Amaryllidaceae
- *Crinum pedunculatum*

Commelinaceae
- *Commelina cyanea*

Cyperaceae
- *Caustis pentandra*
- *Schoenus imberbis*
- *Scirpus nodosus*

Flagellariaceae
- *Flagellaria indica*

Iridaceae
- *Patersonia glabrata*

Liliaceae
- *Caesia vittata*
- *Dianella caerulea*
- *D. revoluta*

Orchidaceae
- *Dendrobium linguiforme*
- *D. speciosum*
- *Pterostylis ophioglossa*

Poaceae
- **Paspalum dilatatum*
- *Phragmites australis*
- *Poa affinis*
- *Spinifex hirsutus*
- *Themeda australis*

Smilacaceae
- *Smilax glyciphylla*

Xanthorrhoeaceae
- *Lomandra longifolia* subsp. *longifolia*
- *Xanthorrhoea arborea*

THE DISTRIBUTION AND CONSERVATION STATUS OF A RARE CONIFER, *MICROSTROBOS FITZGERALDII* (PODOCARPACEAE)

JIM SMITH

(Accepted for publication 9.12.1980)

ABSTRACT

Smith, Jim (*School of Biological Sciences, Sydney Technical College, Ultimo, New South Wales, Australia* 2007) 1981. *The distribution and conservation status of a rare conifer*, Microstrobos fitzgeraldii (*Podocarpaceae*). *Cunninghamia* 1 (1): 125–128. Eighteen localities in the Blue Mountains were surveyed to provide information on the distribution and present status of *Microstrobos fitzgeraldii*. A total of 203 plants were found confined to 6 localities. The observed habitat requirements of the species are described.

INTRODUCTION

With the exception of *Callitris* and *Actinostrobus* most of the eleven Australian conifer genera are today restricted to small, wet refuge areas along the east coast. One of these, the genus *Microstrobos*, is endemic to Australia and contains only two species, one (*M. niphophilus* Garden & Johnson), restricted to alpine areas of Tasmania, and the other, *M. fitzgeraldii* (F. Muell.) Garden & Johnson, a small shrub with weak straggling branches up to 2 m long, to waterfalls in the Blue Mountains of New South Wales. This latter habitat is being gradually altered by increasing urban development in the catchments of the waterfalls.

Mueller (1880) made the first record of the distribution of *Microstrobos fitzgeraldii:* "In silvis densissimis madidis tractus altioris "Blue Mountains" dicti rarissimum ad cataractam Katoomba". (In very thick and wet forests of the elevated tract called the Blue Mountains, very rare at Katoomba Falls). Baker & Smith (1910) noted "In New South Wales this species is found at the base of most of the chief falls on the Blue Mountains. The material upon which this investigation was based was obtained at Lower Falls at Leura . . .". Moore & Betche (1893) and Dallimore & Jackson (1966) merely repeated the distribution information from the earlier publications. Thompson (1961) gives the collection localities of all National Herbarium of New South Wales specimens. All were from Wentworth Falls with a single specimen being recorded as found at "bottom of Leura Falls and Wentworth Falls". All collections since 1961 and prior to the present survey have been made at Wentworth Falls.

Following the discovery of this plant at Bonnie Doon Falls (Grid ref. 281346, Katoomba 1:31 680 sheet) a survey was undertaken of all likely waterfall localities in the upper Blue Mountains. Counts were made of the number of plants present at the various localities (Figure 1) which could be readily visited, and inaccessible ledges were surveyed with binoculars.

RESULTS AND DISCUSSION

Results of survey

Table 1 details the numbers of plants found at 6 of the 18 localities studied. No plants were found at the other localities on the south facing side of the main Blue Mountains ridge, namely Den Fenella (Grid ref. 358326, Katoomba 1:31680), waterfalls of 'The Valley of Waters' as far as Vera Falls (351333 to 355322), Gordon Falls (325326), Linda Falls (311330), waterfalls near the Devils Hole (280328), Mermaids Cave (266425), Porters Pass (261446) and Rienits Pass (Mt Wilson 1:31 680 sheet, grid ref. 242482) nor associated with localities on the north facing side: Minne-Ha-Ha Falls (Katoomba sheet, grid ref. 318386), Govetts Leap Falls

TABLE 1

Distribution of *Microstrobos fitzgeraldii*

Locality*	Grid reference Katoomba 1:31 680 sheet	No. of plants	Aspect	Drainage to
1 Wentworth Falls (i.e. the waterfall formed by the upper part of Jamison Creek).	366325	92	South	Kedumba River, Jamison Valley
2 The small unnamed waterfall 150 m west of Wentworth Falls.	366325	31	South	Kedumba River, Jamison Valley
3 The small unnamed waterfall 100 m west of Gordon Falls.	325326	7	South	Kedumba River, Jamison Valley
4 Leura Falls	314332	41	South	Kedumba River, Jamison Valley
5 Katoomba Falls	295325	12	South	Kedumba River, Jamison Valley
6 Bonnie Doon Falls	281345	20	South	Megalong Creek, Megalong Valley

* There are no permanent waterfalls with significant vertical drops east of Wentworth Falls.

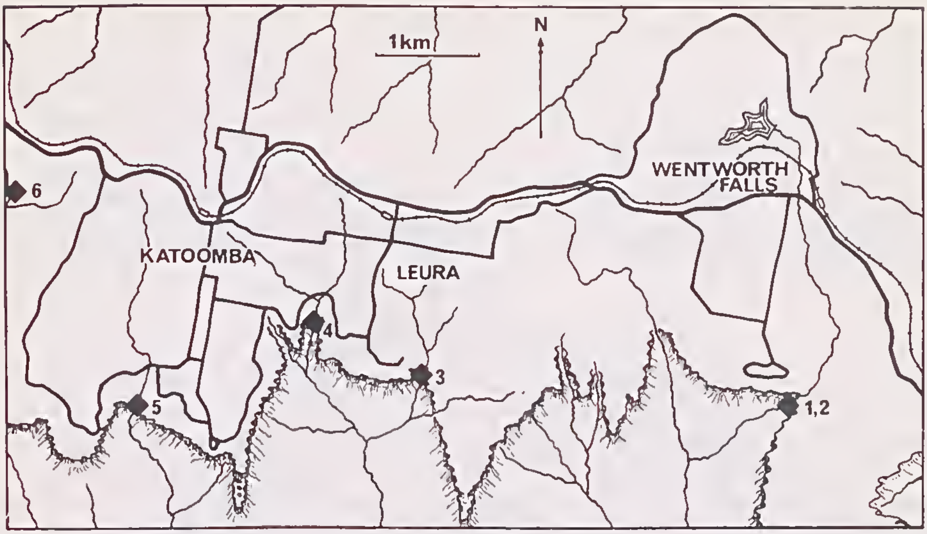

Figure 1. Locality: 1. Wentworth Falls; 2. Unnamed waterfall 150 m W of 1; 3. Unnamed waterfall 100 m W of Gordon Falls; 4. Leura Falls; 5. Katoomba Falls; 6. Bonnie Doon Falls.

(305443), Horseshoe Falls (302450) and Victoria Falls (Mt Wilson sheet, grid ref. 290512). The total number of plants known to exist in all localities is 203. The extreme limits of its distribution lie only 8 km apart. The range in altitude is from 600 m (bottom of Wentworth Falls) to 900 m (top of Bonnie Doon Falls).

Habitat requirements

Thompson (1961) summarized the situations in which specimens had been found: "on wet rocks located within the range of the spray of waterfalls". Most plants are found on the eastern side of waterfalls and receive spray carried from the waterfall by the prevailing westerly winds in this area. They are never found drenched by the main flow of the larger waterfalls (localities 1, 4, 5 and 6 in table 1) but are on either side where the spray is lighter in intensity. However, they do occur directly below the very small waterfalls (2 and 3).

Plants also colonize ledges behind vertically falling water, and ledges which receive spray caused by deflection of falling water. As well, they have been recorded from inside caves beside waterfalls; these plants do not receive spray from the waterfall but depend on seepage through permeable strata inside the cave. They can occur also on ledges receiving similar seepage but not associated with caves e.g. a row of plants extends 30 m westward of site 2.

No plants have been found in caves which are not close to waterfalls, even if they have similar seepage lines. The wet rocks and ledges colonized by *Microstrobos* are always of sandstone; it is never found growing on the shale exposed at the lower levels of some of the waterfalls.

Ecological condition

At all sites some dead branchlets are found on the shrubs and this is considered normal. Many of the plants in the main concentration at the base of the Wentworth Falls (National Pass level), however, carry extensive areas of dead leaves, and those closest to the falls have branches covered in slime and particulates. This may reflect the gradual drying up of this area and pollution of the creek by raw sewage and septic tank drainage. Some plants here have extensive areas of exposed roots, a condition not seen in other areas; soil erosion due to excessive run-off from cleared areas in the Jamison creek catchment is occurring. By comparison plants at locality 2, on a nearby but undisturbed drainage system, do not show these symptoms.

At all locations small healthy plants are found, indicating that the species is continuing to establish itself.

All plants found are in Blue Mountains City Council reserves. It is recommended that control of all sites where *Microstrobos fitzgeraldii* is found be transferred to the National Parks and Wildlife Service to ensure survival of this rare plant.

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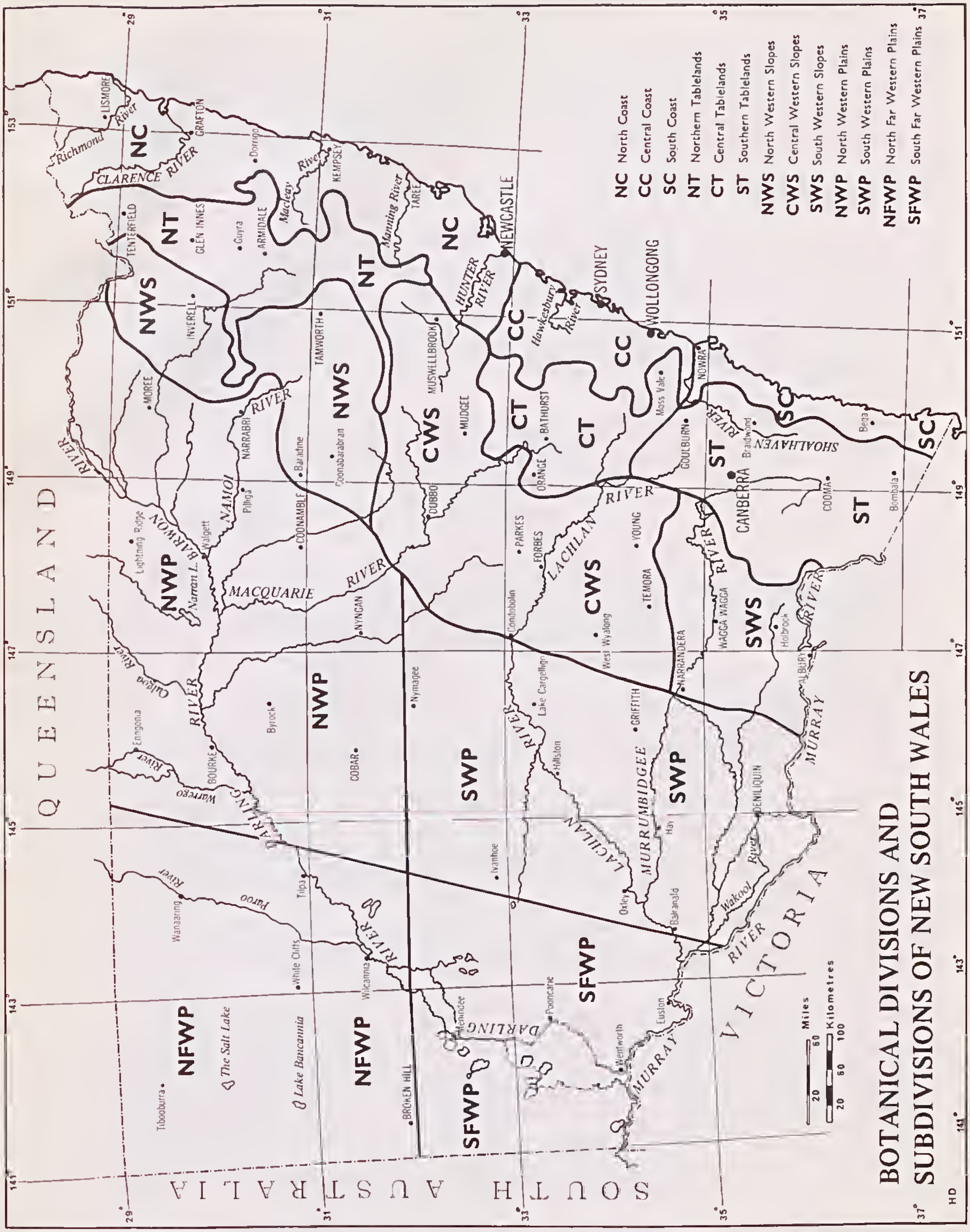

For explanation and description of the Botanical Divisions and Subdivisions of New South Wales see Anderson, R. H. (1961). Introduction. *Contr. New South Wales Natl. Herb. Fl. New South Wales* Nos 1–18, pp. 1–15.

NOTICE TO CONTRIBUTORS

Papers dealing with all aspects of vegetation mapping and plant community descriptions, including floristic lists and ecological data of value for land use and environmental impact studies, are considered for publication in *Cunninghamia.* Papers dealing primarily with New South Wales or with comparative data from New South Wales and neighbouring states will be given preference over those dealing exclusively with other Australian states or other countries. The latter will be considered on the basis of their relevance to New South Wales. Articles of limited scope may be published as Reports or Short Communications. Papers are refereed.

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There is a range of different headings; the main headings should be centred, lesser ones placed at the left-hand margin. It would be helpful if authors could indicate in the margin the relative importance of a heading by use of ringed capital letters, e.g. (A) for main headings, (B) for secondary headings and (C) for tertiary headings, etc.

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Abbreviations and units. SI units (metre, kilogram etc.) are to be used. Statistics and measurements should always be given in figures, e.g. 10 mm, except where the number begins the sentence. When the number does not refer to a unit of measurement, it is spelt out where the number is less than 10. The Printing Style Manual, New South Wales Government Printing Office, or the annotated CSIRO Style Guide, (both available at the National Herbarium of New South Wales) should be consulted for spelling, abbreviations and other conventions.

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Watt, A. S. (1947). Patterns and process in the plant community. *J. Ecol.* **35**, 1–22.

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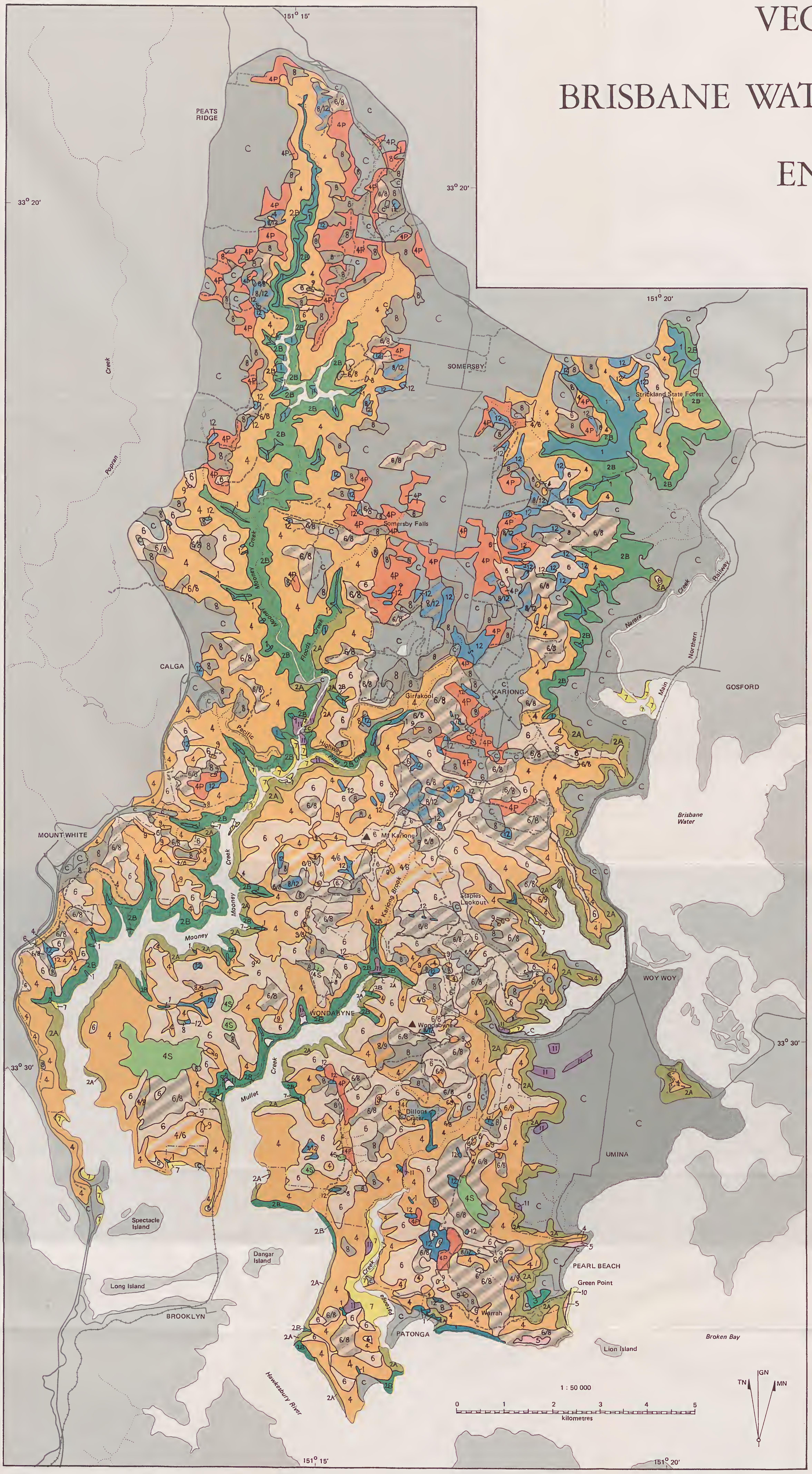
VEGETATION
OF
BRISBANE WATER NATIONAL PARK
AND
ENVIRONS

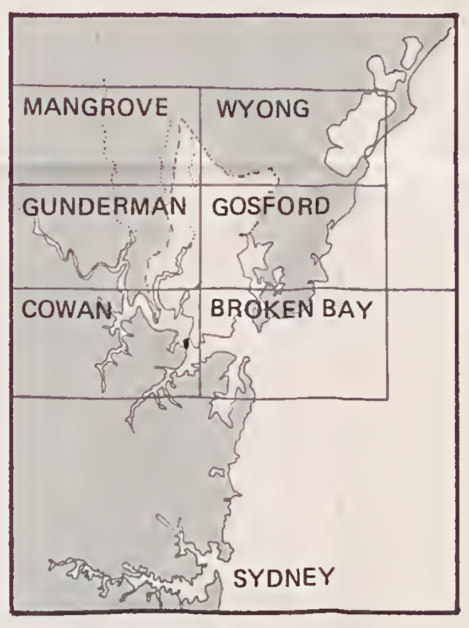
by J. S. BENSON & H. FALLDING



PLANT COMMUNITIES

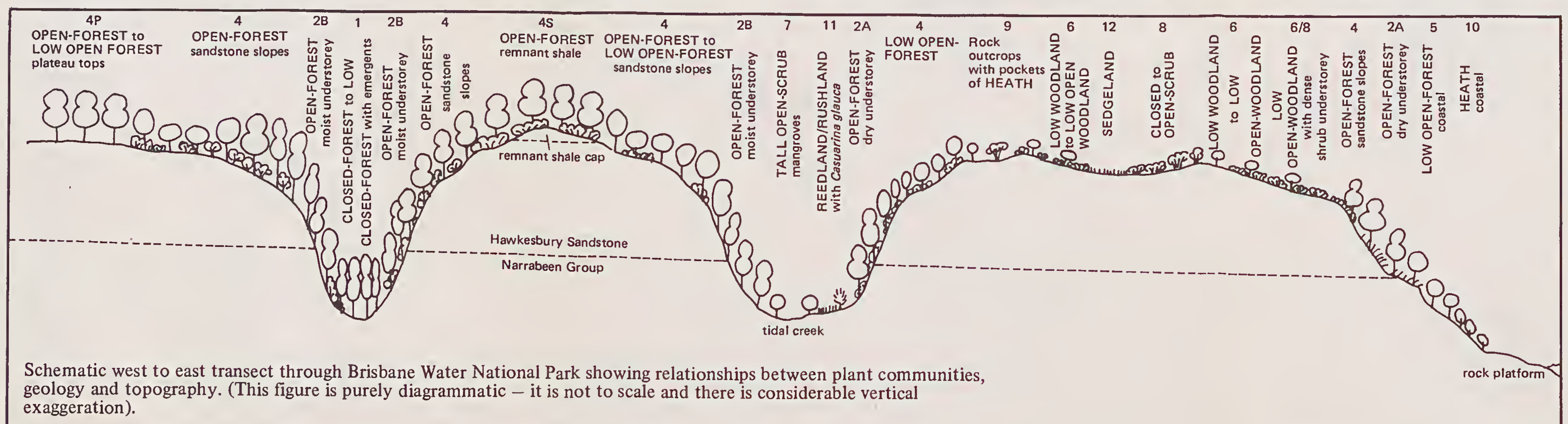
1	CLOSED-FOREST to LOW CLOSED-FOREST with emergent trees; gullies, usually on Narrabeen Group geology. "Rainforest" species, with Myrtaceae and Cunoniaceae important.
2A	OPEN-FOREST, dry understorey; Narrabeen group geology. *Angophora floribunda/Casuarina torulosa* with dry shrubs, *Pultenaea flexilis, Oxylobium ilicifolium* etc. or *Pteridium esculentum.*
2B	OPEN-FOREST, moist understorey; Narrabeen Group geology. *Eucalyptus deanei/Syncarpia glomulifera/ Angophora floribunda,* with "rainforest" species often in understorey.
3	OPEN-FOREST, coastal alluvial flats; restricted to south of Pearl Beach. *Eucalyptus maculata/Angophora floribunda,* often with moist understorey.
4	OPEN-FOREST to LOW OPEN-FOREST, dry understorey; Hawkesbury Sandstone. *Eucalyptus piperita* subsp. *piperita/E. gummifera/Angophora costata.* Rich sclerophyllous shrub understorey.
4P	OPEN-FOREST to LOW OPEN-FOREST, Hawkesbury Sandstone; plateaux, deep yellow earth soils. *Eucalyptus gummifera/E. sieberi/E. punctata.* Shrub understorey with *Proteaceae* important; *Doryanthes excelsa* conspicuous.
4S	OPEN-FOREST, remnant shale cappings; sandy clay soils, ridge tops; restricted. *Eucalyptus globoidea/ E. umbra/E. gummifera.* Distinctive understorey species composition with *Pultenaea ferruginea, Acacia myrtifolia* and *Banksia spinulosa.*
5	LOW OPEN-FOREST, coastal; Narrabeen Group, Pearl Beach area only. Stunted trees, *Eucalyptus botryoides/E. umbra/Angophora costata/Banksia integrifolia.*
6	LOW WOODLAND to LOW OPEN-WOODLAND, dry understorey; Hawkesbury Sandstone, sandy soils. *Angophora costata, Eucalyptus umbra/E. eximia/E. haemastoma.* Includes pockets of mallees, *E. luehmanniana* and *E. multicaulis.*
7	TALL OPEN-SCRUB, Mangroves; alluvium subject to tidal inundation. *Avicennia marina* var *australasica/ Aegiceras corniculatum.*
8	CLOSED to OPEN-SCRUB; Hawkesbury Sandstone, poorly drained conditions. *Banksia ericifolia/Hakea teretifolia.*
9	ROCK OUTCROPS with pockets of HEATH; Hawkesbury Sandstone. *Casuarina distyla/Baeckea brevifolia/ Darwinia fascicularis* and monocotyledonous species.
10	HEATH, coastal; Narrabeen Group; restricted to areas south of Pearl Beach, subject to salt spray. *Banksia integrifolia/Leptospermum laevigatum,* with smaller shrubs of *Westringia fruticosa.*
11	REEDLAND-RUSHLAND with WOODLAND of *Casuarina glauca;* in estuaries on alluvial flats and along tidal channels. *Juncus kraussii/Phragmites australis* on lower ground. *Melaleuca styphelioides/Casuarina glauca* on higher ground.
12	SEDGELAND; Hawkesbury Sandstone plateaux with impeded drainage and moist organic soils. Dominated by sedges and shrubs such as *Sprengelia incarnata* and *Banksia robur.*
C	Cleared and/or disturbed.

Some areas of vegetation comprise mosaics of two communities (e.g. 6/8) which could not be shown separately at this scale of mapping.



Sheet names refer to Lands Department 1:25 000 topographic series.

Major Roads	———
Fire Trails	- - - - - -
Railways	++++++++
Creeks	....
National Park Boundary	— . — . —
Waterways	☐
Land outside mapped area.	▨


4P
OPEN-FOREST to LOW OPEN FOREST plateau tops
4
OPEN-FOREST sandstone slopes
2B
OPEN-FOREST moist understorey
1
CLOSED-FOREST to LOW CLOSED-FOREST with emergents
2B
OPEN-FOREST moist understorey
4
OPEN-FOREST sandstone slopes
4S
OPEN-FOREST remnant shale
remnant shale cap
4
OPEN-FOREST to LOW OPEN-FOREST sandstone slopes
Hawkesbury Sandstone
Narrabeen Group
2B
OPEN-FOREST moist understorey
7
TALL OPEN-SCRUB mangroves
11
REEDLAND/RUSHLAND with Casuarina glauca
tidal creek
2A
OPEN-FOREST dry understorey
4
LOW OPEN-FOREST
9
Rock outcrops with pockets of HEATH
6
LOW WOODLAND to LOW OPEN WOODLAND
12
SEDGELAND
8
CLOSED to OPEN-SCRUB
6
LOW WOODLAND to LOW OPEN-WOODLAND
6/8
LOW OPEN-WOODLAND with dense shrub understorey
4
OPEN-FOREST sandstone slopes
2A
OPEN-FOREST dry understorey
5
LOW OPEN-FOREST coastal
10
HEATH coastal
rock platform

Schematic west to east transect through Brisbane Water National Park showing relationships between plant communities, geology and topography. (This figure is purely diagrammatic – it is not to scale and there is considerable vertical exaggeration).

Compiled and prepared by the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney.

Vegetation survey, mapping and description by J. S. Benson and H. Fallding.

Base map by E. Bie.

Map reliability: compiled from Lands Department 1976 colour aerial photography, scale 1 : 25 000, with extensive field checking.

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CUNNINGHAMIA Volume 1 (1) 1981

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